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NATURE STUDY

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NATURE STUDY

BY GRADES

A TEXT-BOOK FOR LOWER GRAMMAR GRADES

BY

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The time has now happily passed when it is necessary to urge the importance of the love and study of nature, or to show how from it have sprung love of art, science, and religion, or how in the ideal school it will have a central place, slowly subordinating most other branches of study as formal and accessory, while it remains substantial. To know nature and man is the sum of earthly knowledge.

G. STANLEY HALL

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ENTERED AT STATIONERS' HALL, LONDON
W. P. 1

TO THE TEACHER

It is the object of this book to aid both teachers and pupils in an examination and study of the common laws and properties of matter found in every school environment; to organize and direct investigations into the secrets of nature; to discover her laws and their relations to us; to stimulate observation and inference; and to enjoy communion with, and to secure profit from, the common things around us.

Bearing in mind that children should study *things* rather than *books*, and that these things must be found within the environment of the children; and, further, that no text-book can be sufficiently comprehensive to include in its lessons all the useful features in the surroundings of any considerable number of schools or homes, it follows, therefore, that many original lessons, based upon the observations and experiences of individual schools, should form an important part of a course in nature study, and must be provided by the teacher.

Most of the lessons included in this text are general in character and may be given in any school; but equal or greater good comes from studying special features of the respective environments of various schools. In doing this, the pupils acquire more readily the true scientific attitude toward nature; appreciate and enjoy better her phenomena; get a more perfect conception of the principles by which nature is governed, and understand more clearly how these principles may be made to serve man's needs. The teacher must be depended upon to direct most of these original investigations, and can get little direct aid from any book except

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suggestions as to methods of procedure in solving original problems.

Before taking up this second book of nature study, it is presumed that the teacher is familiar with the explanations given in Book I, and that the pupils also have done the work there provided.

The subjects forming the basis of the Fourth Year's work are chosen from the realm of thought and experience of pupils of this age, and develop further the work given for the lower grades. The language used is simple, and the directions and experiments given are understood easily by the children. The teacher may modify any lesson here given, or even substitute a new one to make it fit better the needs and conditions of the school.

Very often the suggestions contained in a single lesson may be expanded with much profit into several lessons, the teacher placing an outline of the required work on the blackboard. Local interest, conditions, and familiarity with the subject, will determine the nature and amount of this work.

When treating a topic which requires continuous observation for several days or longer to complete, but which for convenience is given in one lesson (as, for example, "Germination"), such questions, directions, experiments, etc., as can be considered the first day are given in proper order in the first paragraphs. Another group of paragraphs will contain the matter that further development and observation might make it desirable to consider the second time the subject receives attention; and so on. Thus the lesson is developed by successive steps taken at intervals of several days, though it is written as a unit for the sake of showing connections and

making easy a review and application. The teacher, from the nature of the work, must determine the best times for recurring to the lesson; and should also provide work from the text or elsewhere for the recitations intervening.

Some physical experience—observing, handling, or experimenting with an object—should always precede or accompany the abstract consideration of it. This important rule determines the relation of the text to the teacher, and the kind and amount of aid the latter can get from the text.

Therefore the teacher must see that the pupils make observations and perform the experiments directed, or equivalent ones, and be ever ready to supplement the questions and illustrations given, in order to insure the comprehension of the properties, principles, or laws involved in the lesson. Care should be taken not to go further than the class can follow, or the pupils will become discouraged. Sometimes perhaps more has been placed in the text than some classes can grasp, but it is easier for the teacher to omit portions than to provide more work herself.

While there is no intention to puzzle either teacher or pupil in presenting the questions and problems herein contained, it is believed to be better pedagogy to leave them unanswered and unsolved than to print the answers and solutions for the pupils to read. The latter process is so much easier and quicker than the former that it would always be chosen, and the pupils would fail to get the educative values of working out solutions by themselves. For this reason few explanations are given in the text. Inability to explain satisfactorily some few things should not discourage effort. There are many truths that scientists cannot explain.

Occasionally, observations, experiments, and questions,

used in treating some of the topics studied in the primary grades, are repeated here. This seems to be almost unavoidable, and is done to bring into consciousness and to systematize the fragments of knowledge the child already has of the subject and to insure the making of proper connections with the new thoughts to be developed in the lesson. In few cases, however, will such apparent repetitions be real ones. The added experience of the ten or twelve year old boy will give the observation or question a content very different from what it had for him when he was only six or eight years of age.

The illustrations are used, in most cases, to explain the arrangement of apparatus, or to show some condition or phenomenon in nature rarely seen by children living in large cities. The latter are usually photo-engravings—the best possible substitute for the real objects. For many of these, as well as for valuable suggestions concerning subject matter, acknowledgments are due to the faculty of the Utah State Normal School and to Professors R. S. Northrop and E. G. Titus of the Utah Experiment Station.

H. H. CUMMINGS.

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FOURTH GRADE—FALL WORK

LESSON I

WHAT THE WEATHER DOES

To THE TEACHER.—The pupils should make simple observations regularly on various features of the weather; and what they see should be recorded upon the blackboard and discussed in the class occasionally. Give the pupils opportunity to observe the different kinds of weather as they occur, and base the lessons, as far as possible, upon what they have seen. The suggestive lessons given here upon different phases of this subject should be given at the time the needed observation work can be done. Other lessons should grow out of these which the teacher may prepare as needed, for the subject should receive occasional attention throughout the year.

1. What does weather do for us? Does it ever help or hinder us in our play? How? In our work? How?

2. How do the different kinds of weather affect the appearance of the landscape? Which do you prefer, a winter scene or an autumn scene? Draw a scene for each season.

3. What good have you seen done by a rain storm? a snow storm? a hail storm? a wind storm?

4. Give an account of any harm that you have ever seen done by any of these storms.

5. Would it be a good thing to have fair weather all the time?

6. Tell what you know about countries where it rarely storms.

7. Should we be glad or sorry when it rains? Why?

8. Tell how different kinds of weather affect plants. What

kind makes them grow? What kind kills many? When do plants grow fastest? What kind of weather have we then? When do plants grow least? What kind of weather have we then?

9. How are animals affected by weather? What care should they receive in hot weather? in cold weather? Consider the horse, cow, dog, chickens, pets, etc.

10. What kind of weather do we have in the spring? in the winter? in the fall? in the summer? Which kind do you like the best? Why?

11. What games do we play in the spring? in the winter? in the summer? in the fall? Does the weather have anything to do with changing our sports? Is it a good thing to change our sports?

12. What tradesmen have much work in summer, but little in winter, owing to the weather? What season of the year is your father busiest? When do you do most work?

13. What harm would be done if a heavy snow storm should occur in summer?

14. A heavy rain storm in the winter time would cause what damage?

15. If you could, what changes would you make in the kinds of weather we have during the different seasons of the year?

16. Would you like to know a day or two beforehand what the weather will be? Why? Of what use would this knowledge be to man?

We will study the weather this year and try to learn more about what it does for us and how to foretell the different changes that are constantly taking place in its conditions.

LESSON II

WHAT WEATHER IS

1. How many kinds of weather can you name?

2. Describe each of the following kinds of weather: cloudy; windy; fair; rainy; cold; hot; sultry.

3. Which kind of weather are we having to-day?

4. Tell all you can about the last heavy rain storm. Did the wind blow? If so, in what direction? What kind of clouds covered the sky? Did the storm make it colder or warmer? How long did it last? How much water fell? Did it thunder or lighten?

5. What good was done by this rain? Did it do any harm?

6. In trying to learn about the weather, what things must we study?

7. Where did the rain come from? Where did the clouds get their moisture? What became of the clouds when the rain had all fallen?

8. What makes the water turn into clouds? Where does the heat come from that evaporates the water? Would there ever be rain were it not for the heat of the sun?

9. What brings the moisture from the sea to fall upon the lands hundreds of miles away?

10. What are the three chief things that go to make up weather?

11. Could we have any of the kinds of weather we have mentioned without either of these three things?

12. What would have been the effect upon the last heavy rain had there been very little heat? if there had been very little moisture?

LESSON III

THE CLOUD

I bring fresh showers for the thirsty flowers,
From the seas and distant streams.
I bear light shade for the leaves when laid
In their noon-day dreams.
From my wings are shaken the dews that waken
The sweet buds every one,
When rocked to rest on their mother's breast,
As she dances about the sun.
I wield the flail of the thrashing hail,
And whiten the green plumes under,
And then again I dissolve it in rain,
And laugh as I pass in thunder.

—SHELLEY.

THE CLOUDS

1. Have you ever noticed the clouds moving? Is their motion slow or rapid? Did they all seem to be going in the same direction, or were they moving about in many directions?

2. What moves the clouds? Do they travel far?

3. What are clouds made of? What do they look like?

4. What is the difference between smoke and steam? What is smoke made of? From what is steam made?

Experiment.—Hold a cold glass in a steam jet, or breathe upon it and see what forms on it. Hold another in a smoky flame and find out what will collect on it.

5. From what did the drops of water come? Where else have you seen drops of water formed in a similar way?

6. Where did the soot come from? Where else have you seen soot that was formed in a similar way?

7. Give other proofs that clouds and smoke are different.

8. How high above the ground are clouds? Have you ever seen them resting on a mountain? Have you ever seen, at a distance, the shadow of a small cloud moving over the ground? Could you tell from this how high the cloud was? Clouds are often thought to be much higher than they really are.

9. Under what conditions are clouds formed? How is steam made?

10. Can we always see our breath, or the steam as it comes from a teakettle? On what kind of day can we see either of these best?

11. Have you ever noticed steam, or *vapor*, rising on a warm day from the ground, as the mud is drying up after a rain? Do you think any vapor ever goes up that we cannot see?

Sometimes vapor can be seen and sometimes it cannot, but it is always being formed when water is drying up, or *evaporating*. When the air is cold enough, vapor can be seen. If the water dries up very slowly, the vapor cannot be seen even on a cold day.

12. Where do you think most clouds are formed? Why?

LESSON IV

KINDS OF CLOUDS

1. About how much of the sky is covered with clouds to-day? Describe them.

2. How much of the full amount of sunshine will they cut off?

3. Describe the different kinds of clouds that you have seen.

4. What kind covers the sky when it is raining or snowing?

When it is storming, so much vapor has risen that the sky is full of it, just as the kitchen may be full of vapor on wash days in the winter time. Such even, dark gray clouds are called *Nimbus*, or storm clouds.

5. When the air is quiet and much vapor is rising from the ground, what kind of clouds do you think the vapor will form when it reaches the cold air in the sky?

6. Have you seen the rounded cloudlike masses of steam formed in the still air near the mouth of a teakettle, or near the exhaust pipe of an engine?

Clouds piled up like great balls of cotton are called *Cumulus* clouds.

7. If you were to blow strongly against these rounded masses of steam above the spout of a teakettle, how would your breath change their form?

8. Suppose a strong wind in the sky should blow against some cumulus clouds, how would it change their form?

9. Why are clouds lying in long, level streaks in the sky called *Stratus*, or wind clouds?

Sometimes on a fair day quite a portion of the sky is covered with small fragments of clouds that look like white feathers. These are called *Cirrus* clouds, and are often very high.

10. Can you tell how such clouds may be formed?

11. By observing clouds, learn to recognize each kind easily in the sky.

No one of these forms—except the first—is often seen covering any considerable portion of the sky unless mixed with other clouds. When two kinds blend, their two names are united in describing them; e. g., *cirro-cumulus* clouds.

12. Mention the four principal forms of clouds and describe the conditions under which each kind may be produced.

13. Make a drawing to represent each kind.

14. When a cloud rests on the ground, what do we call it?

15. What makes it rest on the ground? Is the air heavy or light when this happens? Give a reason for your answer.

16. Notice how much of the sky is covered with clouds each day and if they interfere with the amount of sunshine that we get.

TO THE TEACHER.—The Weather Bureau will furnish free a colored chart illustrating the different kinds of clouds.

LESSON V

THE WIND

1. What wind is blowing to-day? What good does wind do? What harm does it sometimes do? Give examples. What is wind?

2. What do we call strong winds that often do great damage? What do we call gentle winds?

The gentlest winds move about two miles an hour. When wind moves as fast as an ordinary train, that is, 40 miles an hour, we call it a *gale*; in a *hurricane* it moves about as fast as the fastest trains—a mile a minute. The strongest winds do not move 100 miles an hour.

3. What wind usually brings a storm in your locality?

4. What time of the year do you have most wind?

5. Make a weather-vane in the manual-training room, and fasten it on some high object away from trees and buildings

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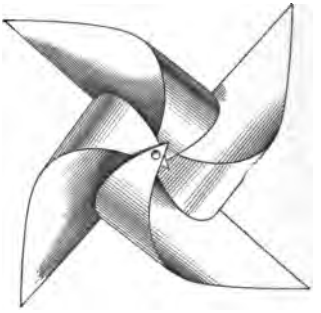
where it will show the true direction of the wind. Notice each day the direction or the absence of wind and record your observations upon the blackboard.

6. Find the average direction of the wind each week; each month.

7. What uses does man make of wind?

Experiment.—Make a toy windmill as follows: Take a square piece of strong, stiff, writing paper and from each corner cut inward nearly to the center, making eight points. Bend four alternate points over the center and pass a pin through them and the center into the end of a wooden handle. A mere breath will make this turn round the pin as an axis.



AN OLD-FASHIONED WINDMILL

8. Tell how the force of the wind turns it.

9. Describe large windmills that you may have seen, and tell about the work that they do.

10. In what other ways does man make use of the force of the wind?

11. How does man protect himself against the bad effects of strong winds? Give examples.

LESSON VI

A RAINSTORM

To THE TEACHER.—At an opportune time, when a rain storm is about to occur, the pupils should observe, as far as possible, all its features and discover its effects. A written account of what they learn would be a good subject for work in language and reading, besides fixing better in their minds what they see. In developing the lesson, use such number work and illustrations as will enable the pupils to understand something of the vast quantities of water that fall, the great power of the gentle forces employed, and the importance of the work that is done by the rain.

1. How can we tell when it is going to rain?

2. Does rain usually occur suddenly, or does it take considerable time to prepare a storm? During what seasons do the most sudden storms occur?

3. Describe how the sky becomes covered with clouds. Where do they seem to come from? Do they change in form as the storm gathers?

4. Does the wind blow, and if so, in what direction? Do the clouds move in the same direction as the wind? Do the upper winds ever blow in a different direction from the surface winds? How can we tell?

5. Does it thunder? Does it lighten?

6. Does the rain at first fall fast in large drops, or slowly in fine sprinkling?

7. In what months does most rain fall in your vicinity? What months have least rainfall during the year?

8. Which kind of rain storm generally extends over the greater area, a sudden thunder storm, or a long, steady rain? Which do you think does the more good?

9. How may the amount of rain that falls be measured? Describe a rain gauge. Why is it deep? Infer reasons for its shape. Make a rain gauge from an empty tin can for use in the school.

10. Measure and make a record of each rainfall as it comes; then, at the end of the month, find the total rainfall. Where should the rain gauge be placed to test properly the rainfall?

11. Measure the water in the rain gauge after a rain storm. Suppose it is an inch deep, how many cubic inches of water fell on a square foot?

Experiment 1.—Measure 144 cubic inches of water (or, if more convenient, of sand in a chalk box,) and place it in a gallon measure. This is the amount that fell on a square foot.

12. About what part of a gallon fell on a square foot? How many gallons fell on a square yard? on a square rod?

13. If 50 gallons make a barrel, how many barrels fell on a space as large as the schoolroom? as large as the school garden?

14. Estimate the amount of rain that fell on various areas.

A man could drown in what fell on the lawn, the door yard, or the street in front of the house, if it were all collected in a cistern.

15. Consider how much fell on an acre; on a square mile; on the whole city.

16. Can you imagine how much fell during the entire storm? If it were all collected into one place, how big a lake would it form?

17. Where did all the water come from? What power

brought it to us from so far away, over mountains and valleys? How wonderful are the forces of nature and how quietly she does her work!

18. If all the rain had remained where it fell, how deep would the water be?

19. Where did all this water go? Did more run off than soak in?

Experiment 2.—Dig in the ground in various places and find out how deep the rain soaked in and made the soil moist.

20. Did it soak to the same depth everywhere? Why not? Consider the kind of soil, the slope of the ground, and other conditions.

21. Explain how the rain benefits the grass, trees, crops, etc.

22. What would be the result if no rain should fall for a few months? Do you remember when such a condition occurred?

23. What became of the rain that did not soak into the ground?

24. As the rain flows away, is it clear or muddy? Why?

25. What damage is sometimes done by high water or by floods caused by heavy rains?

RAIN IN SUMMER

How beautiful is the rain!
After the dust and heat,
In the broad and firey street,
In the narrow lane,
How beautiful is the rain!

How it clatters along the roofs,
Like the tramp of hoofs!
How it gushes and struggles out
From the throat of the overflowing spout!

Across the window-pane
It pours and pours;
And swift and wide,
With a muddy tide,
Like a river down the gutter roars
The rain, the welcome rain!
—LONGFELLOW.

LESSON VII

AIR PRESSURE

Experiment 1.—Make a small hole in the bottom of a baking powder can. Cover the hole with the end of the finger and fill the can with water. Place a heavy paper over the top and hold it on while you quickly turn the can upside down. Remove the hand that holds the paper in place.

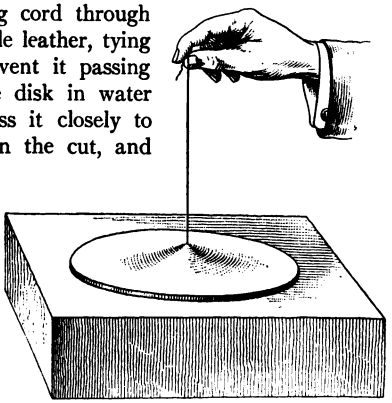
1. Why does not the water run out? In what direction does the air press in holding up the water? What keeps the air from pressing on the water in any other direction?

2. Now remove the finger from the hole, and what takes place? In what other direction does the air press on the water when the hole is opened? Tell why the water falls.

3. Cut a square inch of paper and lay it on the floor. If at sea level, the column of air resting on that piece of paper and reaching as high as the air goes, would weigh nearly fifteen

pounds. The air, then, is pressing in all directions at this rate.

Experiment 2.—Pass a strong cord through the center of a round disk of sole leather, tying a knot in the lower end to prevent it passing through the leather. Soak the disk in water until it is quite soft, then press it closely to any smooth surface, as shown in the cut, and attempt to pull it away.



A LEATHER "SUCKER"

4. Stick the leather sucker to a stone. Why can you lift the stone? How can you get it off? Why?

5. Why will not molasses flow from the large hole in a barrel until a small one is made in the upper side of the barrel?

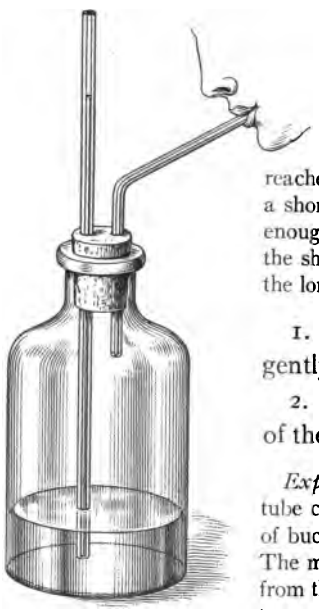
In a canyon out west is a great reservoir filled with water. A large wooden pipe, bound with strong iron bands, carries the water from the reservoir down the canyon at a very steep grade. One day the man in charge suddenly closed the great valve at the reservoir, shutting off the water from entering the pipe. The water which already filled the pipe continued by its great weight to flow downward, leaving the upper end empty. A long section of this empty pipe was crushed in. What crushed it in? Some students of the college near there had told the man what would happen if he turned off the water suddenly, but he would not believe them.

Experiment 3.—Put one end of a bent tube into a glass full of water, with the other end hanging down the outside. Why does not the water flow out?

6. Suck the air out of the tube and tell what happens. Why?
7. Explain the action of the siphon. Tell some of its uses.
8. Tell about other examples of air pressure.

LESSON VIII

THE BAROMETER



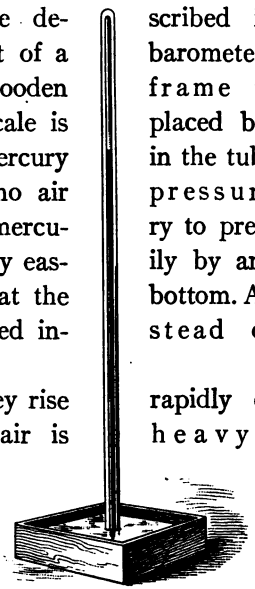
Experiment 1.—Take a wide-mouthed bottle one fourth full of water and fitted tightly with a cork having two small holes through it. Down one of these holes push a long, straight, glass tube until its lower end reaches below the surface of the water. Put a short bent tube into the other hole, not far enough to reach the water. Blow through the short tube and tell what takes place in the long one.

1. What happens when you blow gently? When you blow hard? Why?
2. Upon what, then, does the height of the water in the long tube depend?

Experiment 2.—Fill with mercury a long tube closed at one end, and tie a sack made of buckskin over the other. Invert the tube. The mercury is so heavy that it falls away from the closed end of the tube a short distance. Now squeeze gently the sack of mercury. What happens to the column in the tube?

3. When the air presses on the sack of mercury, what happens?
4. If the air pressure is great, what is the effect upon the column? If the air pressure is slight?

When properly made, the tube described in Experiment 2 forms the chief part of a barometer. Generally a barometer is set in a wooden frame to protect it, and a carefully graded scale is placed behind it so that the height of the mercury in the tube can be read with ease. Since no air pressure can reach the upper surface of the mercury to press downward, the column is moved very easily by any pressure on the sack of mercury at the bottom. An open vessel of mercury is often used instead of the sack and acts in the same way.



SIMPLEST FORM OF THE BAROMETER

5. Does the smoke from a chimney rise rapidly or keep near the ground when the air is heavy? Why? In what direction do very heavy things tend to move?

6. Will a chimney draw better when the barometer is high or when it is low? Why?

7. Explain why a balloon rises. What effect will high or low air pressure have upon its flight?

8. In some coal mines explosive gases ooze out of crevices in the coal seams all the time. Does more come out when the air is light, or when it is heavy?

9. Is the danger of explosions in such mines greater when the barometer is high or when it is low?

LESSON IX

USE OF THE BAROMETER

1. Where does the moisture come from that forms clouds?
2. Where does evaporation chiefly take place, near the

earth's surface or far from it? Tell where you have seen water drying away.

3. How does vapor get up to where it forms clouds? What will make air so light that it will rise?

Experiment.—By means of "smoke paper," or a small, sensitive windmill, show that the hot air is rising over a lamp chimney, radiator, stove, or other place where a portion becomes heated. Explain the draught of the chimney.

4. When the air near the ground becomes very warm, and at the same time moist, what movement usually takes place?

5. If this air rises, the moisture goes with it. Does an upward movement of air over a large area cause the barometer to rise or fall? Why?

6. What change takes place in the moisture of this rising air when it reaches the cold upper regions? What happens when warm moist air from the ocean is blown against high mountains? From what we have already learned, explain how rain is produced.

7. How does the barometer generally move just before a storm? Why?

8. If a great body of air is rising from one place, what movement of air must be taking place somewhere else?

9. If the air is falling over a large area, how is it influencing the barometer there? Why?

10. Can air, falling from the cold, upper regions into warmer, moister places cause a storm? Why?

11. Why does a high barometer indicate fair weather?

12. Why does a thunder shower usually happen on a hot, sultry day?

13. Watch the barometer and tell when a storm is coming.

LESSON X

CONDITIONS AFFECTING RAINFALL

1. Tell how rain is made.

2. What kind of weather causes fastest evaporation?

3. How does rapid evaporation affect rain?

4. What part of the earth is hottest? Where, then, will there be the most rapid evaporation?

5. What can you say of the amount of rainfall in those regions?

6. When is the sun farthest north of the equator?

7. When is it farthest south of the equator?

8. What influence has the sun upon evaporation? Compare the power of its direct and slanting rays in this regard.

9. Why does the rainy season in Mexico begin in June, while in Bolivia it begins in December?

10. Why do the daily rains in the Tropics follow the sun in its journey north and south of the equator?

11. Since the most evaporation occurs over the ocean, how does the vapor get inland to make our rain?

12. What wind in your locality most frequently brings rain? Do you think this wind comes from the ocean?

13. What conditions must the vapor in the clouds meet to cause rain?

14. In how many ways is the vapor carried in the air made cool enough to condense and fall as rain or snow?

LESSON XI

OBJECTIVE REPRESENTATIONS

TO THE TEACHER.—Appropriate graphic or objective representations of data suggested by the pupil are very helpful in discovering relations and making inferences. Children naturally use one set of objects to stand for others. In their playhouses, chips and stones stand for people and animals, or for furniture or what not. Lead pupils to invent, as they need them, their own methods of representing the results of their observations of the weather, and to keep a careful record of them on the blackboard or in some fitting, objective way. The following examples will illustrate some ways in which this may be done.

I—TEMPERATURE

1. Make a mark on the blackboard that will represent the temperature to-day.

2. What was the temperature yesterday? Represent it by another mark beside the first. Is it longer or shorter than the first? Why?

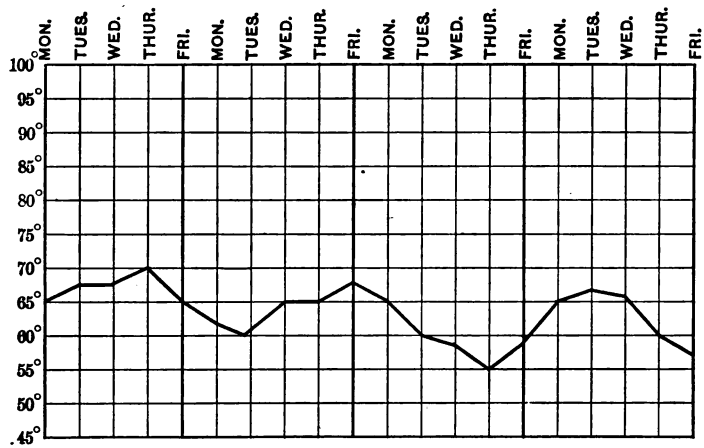
3. In like manner make a series of upright lines that will represent the temperature each day during the week.

4. Number or name the lines to show for which day each one stands.

5. Can you tell from these upright lines just how high the thermometer was each day of the week? Can you arrange a diagram that will do this?

6. How could this be done easily on cross-section paper?

7. Let each vertical line on a piece of cross-section paper stand for one hour. Name them 9, 10, 11, 12, 1, 2, and 3 for the hours that school is in session. Let each horizontal line represent one degree of temperature. Give one of these



RECORD OF DAILY TEMPERATURE

The height of the barometer may be shown in a similar way.

the number corresponding to the reading of the thermometer at 9 o'clock, and the others in order above and below.

8. At 10 o'clock note the change in temperature and make a line from the point indicating the height of the thermometer at 9 o'clock to the one that will show the height at 10 o'clock.

9. In like manner, at the end of each hour, extend the line to indicate the temperature (See page 127, Book I). A diagram of small squares on the blackboard will serve as well.

II—AIR PRESSURE

1. Tell how the height of the barometer can be recorded in a similar way.

2. Could the same piece of cross-section paper, or the same blackboard diagram, be used for both readings?

3. How might differently colored chalk aid to do this?

4. Instead of indicating the readings each hour for a week, how may such a diagram be made to show the average daily readings for a month?

III—Cloudiness

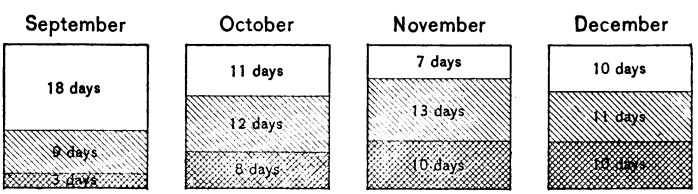
1. Think of some way to represent on the blackboard a fine clear day; a cloudy day; a rainy or stormy day.

2. What colored chalk will be suitable to represent each of these three conditions if you wish to use colors?

3. If a square on the blackboard filled with heavy, double shading lines represents a stormy day, what will represent a cloudy day? a fair day?

4. At the end of the month, how may a large square be divided and marked so as to show the number of fair days, of cloudy days, and of stormy days in the month?

5. Make such a card at the end of each month, and at the end of the year fasten them together and they will make a record of the year's cloudiness.



Cloudiness Represented

The top space indicates fair weather; the middle one, cloudy, and the bottom one stormy. Twelve of these squares may be drawn on a large card to form a chart, or bound together as the leaves of a book.

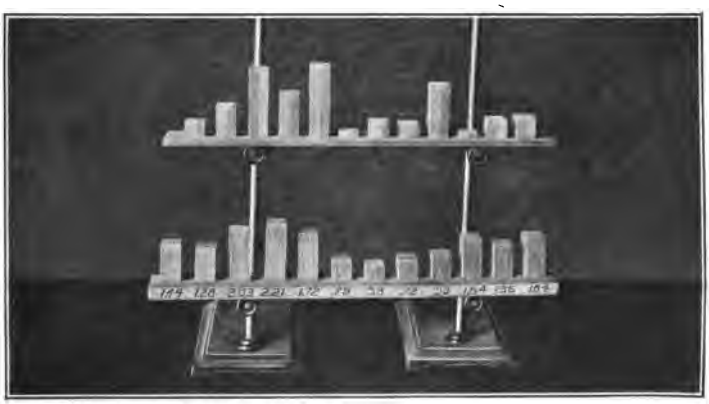
IV—Rainfall

1. How may the amount of rainfall each month be represented on the blackboard?

2. If you had twelve bottles of the same size and shape, how could you represent this much better?

3. Can you think of any other ways of representing each month's rainfall?

Experiment.—At the end of each month, saw accurately from the end of a square picket, a block to represent exactly the total rainfall of the month, and fasten it to a strip of smooth wood—a piece of lath will do. Write the name of the month and the depth of the rainfall under each block. At the end of the year the strip to which all the blocks are fastened may be cut so as to show the total year's rainfall.



Rainfall Represented

The lower blocks represent the average rainfall in Salt Lake City each month for thirty years, beginning on the left and with January, which averages 1.44 inches, and ending with December on the right with an average of 1.64 inches. The total annual rainfall there averages 16.19 inches.

The upper blocks represent the rainfall by months for the current year, a new block being added by the pupils at the end of each month until the year's record is complete. A glance shows how the rainfall in any month compares with the average for that month.

4. Think of ways in which the lengths of day and night, the average direction of the wind, and other things learned through observation, may be represented by drawings or objects.

5. Of what value to you are such representations?

LESSON XII

NATURAL HISTORY CALENDAR

TO THE TEACHER.—At the same time that the pupils are studying the weather, they should also observe animal and plant life, that the big relations between these three things may be discovered. Encourage free discussion in class of the observations of the pupils, and make a special detailed study of any animal, plant, or condition that attracts their attention greatly.

1. What plants are blooming now? Which are seeding? Are any shedding their leaves? Bring specimens to the class and discuss them.

2. Which have already finished the year's work and died?

3. Are any seeds germinating now? If so, what are their chances to grow and mature? How came they to be so late? Bring samples to the class.

4. What fruits are gone? Which are just ripening? Which will keep during the winter?

5. What birds are seen now? Which have gone for the winter? Have any come to spend the winter with us? Mention examples.

6. Are toads, frogs, snakes, lizards, etc., as numerous now as in the summer time? Why? Where do they go to spend the winter?

7. Mention all the insects that you can see to-day. Which have disappeared?

8. What becomes of most insects in cold weather? Have you seen any changes taking place in them?

9. Catch caterpillars and keep them in a larvæ box until they make their winter cocoons.

If kept in a cool place, they may be seen to come out as perfect moths or as beautiful butterflies in the spring.

10. Find out how ants and bees and earthworms pass the winter, and when they disappear.

11. What are the larger wild animals doing to prepare for winter? Do any of them go to warmer countries?

12. How may a record of the things seen be kept in the most useful way? Can you think of a better way than writing in the form of a story, the things seen? Think how these facts may be tabulated so as to be seen and compared at a glance.

NATURAL HISTORY CALENDAR, 19—

NAME_____

Date		*Observation*	*Where Seen*	*Condition What Doing*	*Remarks*
Sept.	20	Robins	In the orchard	Perched in trees	
"	21	Butterfly	On goldenrod	Seeking food	
Oct.	1	Choke Cherries	In canyon	Getting ripe	Blue birds had eaten many
"	2	Wild Ducks	On the wing	Flying toward lake	
"	2	Caterpillar	Under fence rail	Making cocoon	Was well protected

13. Do any animals change their garb as winter approaches?

14. What plants die in the fall? What have such plants done to insure more plants like them next year?

15. What plants have roots that live all the winter, but tops that die?

16. How are crops cared for during the winter? Consider fruits, vegetables, grain, hay, etc.

17. Notice the many changes that take place in the animals and plants around you during the fall months, and tabulate the most important things on the blackboard or write them in your Natural History Calendar.

18. Find out reasons as far as you can for the changes that you notice.

LESSON XIII

THE STARS

The sad and solemn night
Hath yet her multitude of cheerful fires,
The glorious hosts of light
Walk the dark hemisphere till she retires;
All through her silent watches, gliding slow,
Her constellations come, and climb the heavens, and go.

—BRYANT

TO THE TEACHER.—This lesson may be assigned at any time when clear nights prevail and recited when the pupils have had time to observe the stars sufficiently. Myths may be used in connection with Orion, Cassiopeia, and other constellations.

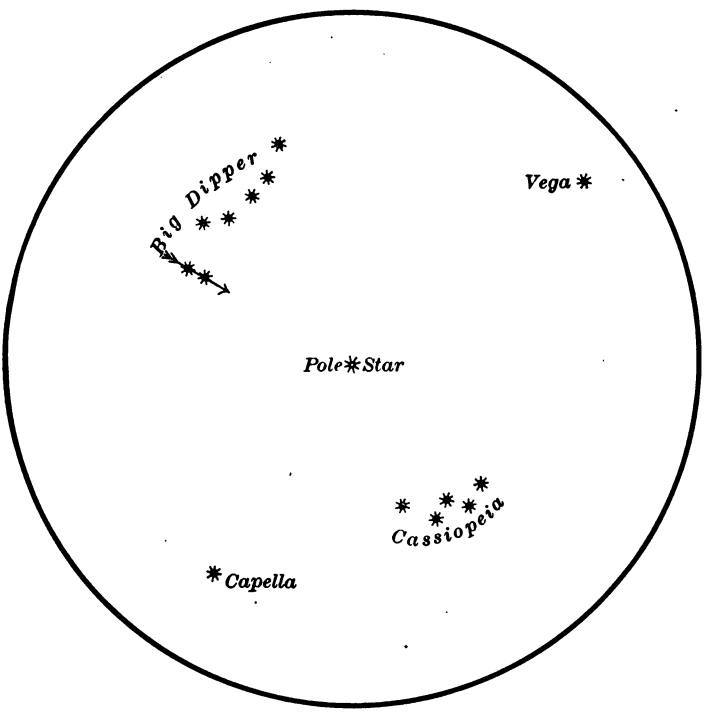
1. Are all the stars of the same size? Can you count the stars?

2. How are they scattered over the sky? Are they in long rows or squares or regular forms?

3. Are all stars "fixed" in their groups, or do some of

them move about among the other stars? Watch some of the brightest stars for a few weeks, and notice if any change their positions among the other stars. Notice especially the morning and evening stars.

4. Learn to name and locate a few very bright stars, as the North Star, Sirius, the Geminii, Vega, and the planets, Mars, Jupiter, Saturn, etc., when they can be seen.



A Few of the Brightest Stars Seen in the Northern Sky

5. Locate a few of the brightest groups of stars, as the

Big Dipper, Little Dipper, Cassiopeia, Orion, and Lyra, all of which are in the northern sky and may be seen on a clear night.

6. Find the Milky Way. Why is it called the Milky Way? Does it always cross the sky in the same place? It is supposed to be made up mostly of stars so far away as to appear to us as a mass of light stretching across the sky.

7. Of what use to us are the stars? How do they help sailors to tell the points of the compass?

8. What daily motion have the stars? Do they all rise and set like the sun and the moon? Watch the Big Dipper; the evening star; the North star.

Stars are supposed to be suns, but they are so far away that even through the biggest telescope they seem to be mere points of light. The nearest star is so far away that, astronomers tell us, it would take a ray of light, which can travel several times around the earth in the twinkling of an eye, two years to reach us. The North Star is so far away that it would take light forty-seven years to come from it to the earth; and, if the star should suddenly be destroyed, its light would continue to shine and we should not know for forty-seven years that anything had happened to it.

LESSON XIV

STUDY OF TREES—SHAPES

TO THE TEACHER.—At the beginning of the year, have the class select several trees and shrubs to study and get acquainted with the changes that they pass through during the whole year. Choose such as have different habits of growth, as a shade tree, a fruit tree, an evergreen tree, a shrub, and a vine. Occasionally the pupils should

write a description of the changes noticed in the trees for a language lesson, and draw them for an art lesson.

1. Do all trees have a similar shape?

2. What is the difference between the shape of the box elder tree and that of the Lombardy poplar?

3. Describe, or draw an outline of, an apple tree; a pear tree; a palm; a pine; an elm.

4. Write a list of trees that are tall and slim. Write another list of trees that are low and spreading.

Trees may be grouped as to shape into four groups, as represented in the illustration.

SHAPES AND DIAMETERS OF TREES

5. Compare the vertical diameters with the horizontal ones, and in each case notice where they cross each other.

6. Mention trees having shapes similar to each of these types.

7. Is the shape of a tree any advantage to it? Why is a poplar tree tall and slim? Where are most of its seeds

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formed? How are they scattered? Does a strong wind break a poplar tree as easily as it does other trees?

8. Why are most fruit trees low and broad? Why are their best fruits found on the highest limbs? What do fruits need to make them develop best? Where are the poorest samples of fruit generally found? Why? Think of reasons for the shape of fruit trees, shade trees, and forest trees that you know.

9. Why do men trim trees? What is the difference between a wisely trimmed orchard and one that has been neglected?

PINE TREE LOADED WITH SNOW

PINE TREE SHEDDING SNOW

To be able to trim trees properly we must know the effect of the shape, and the needs of the trees for much or little foliage, and how to distribute it to meet their needs.

10. Study the shape of the pine. Why is its foliage arranged around the trunk in layers that grow longer and longer from the top to the bottom, making the outer surface of the trees look like the rows of shingles on the roof?

11. Do the pictures opposite suggest any reason for the shape of pine trees?

12. Why are cocoanuts placed at the top of the tall palms on which they grow? What danger to the fruit is thus overcome? When ripe, why does not the fruit break when it falls so far to the hard ground? Is the thick husk of any other use to the plant? How are cocoanut palm seeds distributed? What kinds of soil do they like best? How does nature secure for them this kind of soil in most cases?

13. What habits of growth make the different shapes of trees?

14. In which kinds do the end buds grow most rapidly? In which kinds do the side buds grow fastest? If the side and end buds grow at the same rate, what shape is produced?

LESSON XV

STUDY OF TREES—TRUNKS

1. Name some trees that have long, slender trunks. Are their branches mostly large or small? Do they grow best in groves or singly? Have you ever been in the woods? Compare trees growing in a forest with those growing singly.

2. Of what use to a tree is a long trunk? This use must be a very important one, as it costs a tree many years' labor to get a trunk.

3. What trees have short, thick trunks? Are any of their branches very large? Are such trees found in dense forests? Do they get as much sunshine as do tall, slim trees? How do they get enough sunshine?

4. In what ways are tall, slim trees of use to man?

5. What benefit do we get from trees having short, thick trunks and wide spreading branches?

6. How do some plants escape the labor of making great trunks for themselves? How do vines get enough sunlight?

7. How do ferns and mosses get along with so little light as comes to them under the trees?

Experiment 1.—From a good sized limb of a nearby tree cut a small piece of bark every week or two in the fall, and see what changes take place in the bark as the autumn advances. Find out just how the trunk and limbs grow thicker, and why the number of rings seen in the end of a tree trunk give us an idea of the age of the tree.

8. How do the trunks of trees grow? How may we tell the age of a tree?

9. What is the use of bark on the trunks of trees?

Experiment. 2—Girdle some useless tree by removing a strip of the bark from around the trunk and note the effect.

10. Describe the different layers of bark. Which part seems dead? Which part is alive? Bring samples of the bark of different trees to the class.

11. Is it a good practice to hitch a horse to the trunk of a valuable tree?

12. What trees can you tell by their bark?

13. Describe the bark of the elm, the locust, the poplar, the pine, the birch, and other trees that you have seen.

THREE TREES

The pine tree grew in the wood,
  Tapering, straight, and high;
Stately and proud it stood,
  Black-green against the sky.
Crowded so close, it sought the blue,
And ever upward it reached and grew.

The oak tree stood in the field.
  Beneath it dozed the herds;
It gave to the mower a shield,
  It gave a home to the birds.
Sturdy and broad, it guarded the farms
With its brawny trunk and knotted arms.

The apple tree grew by the wall,
  Ugly and crooked and black;
But it knew the gardener's call,
  And the children rode on its back.
It scattered its blossoms upon the air,
It covered the ground with fruitage fair.

LESSON XVI

STUDY OF TREES—BRANCHES

1. What trees have short trunks that divide up into branches? Do such trees have large branches?

2. What trees have trunks that extend from the ground to the top of the tree? Are the branches of such trees large or small?

3. Are the lower branches generally larger or smaller than the upper ones?

4. What would probably be the effect if the top branches were much longer than the bottom ones?

5. Are there generally more branches on one side of a tree than on the other? Why do branches grow from all sides of the trunk?

6. What trees have branches that grow at almost right angles with the trunk? Which form an acute angle with the trunk? Do any trees have branches that slope downward from the trunk? Think of some purpose in branches leaving their trunks in these three different directions.

7. What trees have tough branches? What trees have branches that are brittle?

Experiment 1.—Take green twigs of about the same size from various trees near by. Bend until they break, and decide which branches are toughest.

8. Which trees need to be tough? Which rarely have any load to bear? Consider fruit trees, shade trees, evergreens, etc.

9. Can you tell the age of a twig? Find the place on a twig that marks a year's growth.

10. Examine twigs and branches and tell how old they are from the joints that are formed each year. Tell what part grew this year; last year; the year before.

11. On twigs from fruit trees notice the leaf scars where leaves used to be. Observe lilac and horse chestnut twigs. Also find places where fruit used to be. What is the difference between a fruit scar and a leaf scar?

Experiment 2.—Examine a young fruit tree and from the fruit scars tell if it bore this year; last year; the year before last.

Thus the history of a tree is written year after year by the truthful hand of nature in its own self.

12. Are trees the only living things whose works nature records within themselves?

13. Is it of any value to us to be able to tell the history of a tree?

14. Draw a twig showing leaf scars, fruit scars, and one or more rings or joints that denote a year's growth.

LESSON XVII

STUDY OF TREES—LEAVES

1. Collect as many different kinds of leaves as you can find. Learn to name each kind at sight.

Experiment.—Strip off all the leaves from a small tree or shrub and note the effect. Try the experiment again in the spring. Of what use to the tree are its leaves?

2. What plants have the largest leaves that you have seen? What plants have the smallest leaves? Does the size of the leaf tell us the size of the plant or tree on which it grew?

3. Are large leaves as numerous on their plants as small ones?

4. Are all leaves of the same shape? Group your sample leaves according to their shapes.

5. Are the edges of all leaves the same? Which are notched? Which are plain? What leaves have pointed tips?

6. What leaves are thick? What leaves are thin? Which are fuzzy? Which are smooth?

7. Do the veins of leaves all run the same way? What leaves have parallel veins? In what way do the veins run in the leaves of the rose? the geranium? the maple? the oak? corn? grass?

8. Do any leaves have an odor? Mention all those you know that have one. Of what use is this odor?

9. What leaves seem to be made up of several small ones?

10. Compare the finely divided leaves of the mosses, ferns, and grasses which are found in the forest shade, with the leaves of the larger trees above them.

11. Do you find very large leaves growing in very shady places?

12. Notice how different kinds of leaves are arranged on their twigs or branches. Which are in pairs opposite each other? Which are alternate? Which grow on the twig so as to form a spiral whorl around it?

13. What is nature's purpose in thus scattering the leaves around on the twigs and branches? Would it do as well for the leaves all to grow on the same side of the branch? Why not?

14. How are the branches placed around the trunk? Is there a purpose in their arrangement? Where are the largest and healthiest leaves found on a tree? Why?

15. Can we tell anything of the condition of the tree by the appearance of its leaves? When the tree needs water, how do the leaves show it? If the roots are diseased, how do the leaves tell us?

16. Examine many plants and trees to see if there are any leaves on them that the sunshine does not reach during some part of the day between sunrise and sunset.

17. Is the space between the trees of a full-grown orchard a suitable place to plant a garden? Why?

18. Are all leaves green? What is the color of birch leaves? of table beet leaves? What leaves are variegated? Describe ribbon grass. Mention greenhouse plants whose leaves are are not green.

NAME EACH OF THESE LEAVES

19. When do most leaves begin to fall? What change takes place in the color of many leaves in the fall of the year? Do

frost-bitten leaves have beautiful colors? How do frost-bitten leaves look?

20. Why is it a good thing that the leaves of most of our trees fall? What would happen to the trees during the winter if they kept all their leaves?

In the Province of Alberta, Canada, very few fruit or shade trees are grown, because untimely snows come there so often and are so heavy that the trees are kept broken down.

21. What trees are best suited to such a condition? Could this trouble be lessened by the right kind of pruning?

22. Draw or paint different kinds of leaves. Collect autumn leaves.

LESSON XVIII

STUDY OF TREES—BUDS

1. Examine leaves just before they fall. How does the tree get rid of its leaves? Examine with a lens a leaf scar where the leaf has been torn off, and one where it has fallen off naturally. How does nature heal the wound in each case? Are there any buds on the twigs when the leaves fall?

2. Where are the new buds? At what time in the fall do these new buds grow most rapidly? Have the new buds anything to do with the falling of the leaves? When are the new buds first formed?

3. Did all the buds that formed last year grow into leaves this year? Examine many twigs and branches and tell what part of the buds formed last year failed to grow this year. Did those that grew have any advantage over those that did not grow?

Experiment.—Mark some buds this fall that you think will not grow and see in the spring if your judgment was good.

4. Why does not careless hoeing kill the weeds? Pull up several kinds of weeds by the roots, and see if you can tell how low down new buds will grow if the top is cut off? How will this knowledge aid us in hoeing a garden?

5. Examine many kinds of buds. How are they covered? Why are some covered with scales? Why are others fuzzy? Has the bitter gum on some of them any use?

6. Consider the coverings of buds in relation to insects, frost, rain, snow, and other dangers.

LESSON XIX

STUDY OF TREES—ROOTS

1. What direction do the roots of a sprouting plant always take? Where are most roots found?

2. Bring to class samples of different kinds of roots. In taking them from the ground, avoid breaking off the fine hair-like rootlets. Wash the roots clean and examine them with a lens.

3. Compare the roots with the tops of plants. Do roots differ in shape? What roots have a single large part going downward with many small roots growing out from it? This is called a *taproot;* it may be compared to what kind of tree trunk?

4. What roots form a bushy mass in the soil? These are *fibrous roots,* and look like the top of what plants?

5. Do roots have a bark or outer protecting covering?

6. Why are weeds so hard to pull from the garden? Why is it a good thing for the plant to be held so firmly in the soil by its roots?

7. What happens to a plant if its roots are killed? What is the chief use of roots to a plant? Mention other uses of roots.

8. What care should be taken of the roots in setting out trees and shrubs? How should the ground be prepared to receive the roots of trees being transplanted?

9. Why should most of the branches be cut off when a tree is transplanted? Can the roots work as well at first in the new place as in the old one?

10. How far from a tree or plant have you seen its roots go for food?

11. How deep have you seen roots grow downward into the ground?

As stems and leaves often bend toward the light, so roots will grow in the direction of food and water.

12. Have you seen them do this? Where?

13. Which plants have more and longer roots, those growing in marshy places or those growing in a dry or desert place? Compare the total roots of a water cress plant with those of a wheat plant. Account for what you find.

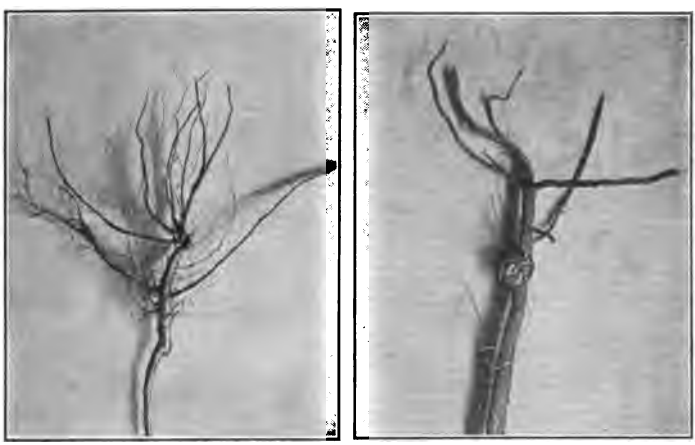
On one barley plant, one hundred eighty feet of roots have been measured, and the roots of the sage brush are known to go twenty-five feet downward. The sand covering the roots of a cottonwood tree, near Lake Michigan, has been blown away, leaving the roots bare, and making a great sand dune just beyond. One root, less than an inch in diameter where it leaves the trunk, measures more than eighty feet in length before it reaches a place where it has not been uncovered. It is here more than half an inch in diameter and

may extend as much farther into the sand. Usually, however, roots do not extend far beyond the shade cast by the branches, nor do they go very deep.

14. Look for roots in river banks, washes, and where men are digging foundations, cellars, etc.

15. What insects injure the roots of trees? Describe any you may have seen.

16. Have you seen tree roots that were diseased? Which



of the apple tree roots in the illustration is healthy, and which is diseased? How can you tell?

THE TREE

I love thee when the swelling buds appear,
And one by one their tender leaves unfold,
As if they knew that warmer suns were near,
Nor longer sought to hide from winter's cold;
And when with darker growth thy leaves are seen
To veil from view the early robin's nest,

I love to lie beneath thy waving screen,
With limbs by summer's heat and toil oppressed;
And when the autumn winds have stripped thee bare,
And round thee lies smooth, untrodden snow,
When naught is there that made thee once so fair,
I love to watch thy shadowy form below,
And through thy leafless arms to look above
On stars that brighter beam when most we need their love.

—JONES VERY

LESSON XX

PLANT RELATIONS TO WATER

TO THE TEACHER.—This lesson should be preceded by a field lesson, or excursion to places where the pupils can see both marsh plants and those that grow in the driest regions accessible to the school. The natural relations and environment of both kinds can thus be studied and samples of plants secured for use in the schoolroom.

1. How do the roots of marsh plants compare with those of desert plants in number? in size? Which are the longer and go down into the soil farther? Can you give a reason for any of the differences that you find?

2. Which have many long, fine, dry, tough roots? Which have short, thick, moist, tender roots? Which need the greater amount of roots, marsh or desert plants?

A class in one of the schools of the arid west dug up an Indian sunflower having only a small top with half a dozen blossoms. The mass of roots extended six feet into the ground and weighed many times that of the top.

3. Why are the leaves of the dry land plants so often few in number and long, slender, dry, and fuzzy or scaly?

4. Compare them with water plants and account for the differences.

5. Mention other differences in these two kinds of plants?

Experiment.—Take equal weights of water cress leaves and those of sagebrush. Dry them thoroughly and weigh them again. This will show which kind contains the more water.

7. Mention some plants that use much water.

8. Mention others that need but little moisture.

9. What features do most water plants have?

10. Describe in a general way the roots, stems, and leaves of desert plants.

11. Can you tell by the looks of a plant whether it needs much or little moisture? How?

12. What crops grow in marshy places?

13. What crops are raised in arid regions?

14. Which of the following plants need much water and which will thrive with but little—rice? corn? rye? celery? cabbage? wheat?

LESSON XXI

SAGE BRUSH

TO THE TEACHER.—Where sagebrush is not found, choose another shrub or weed growing near the school and have its uses studied in a similar way.

Sagebrush is a common plant throughout the western half of the United States, and has done so much for the farmer that its work and nature should be known.

1. Bring samples of sagebrush to class to study.

2. How large is the sagebrush? What is its shape?

3. Describe its leaves. What is their size? shape? color?

4. Is their surface smooth or fuzzy? Do many leaves grow on one bush?

5. Is sagebrush an evergreen, or does it shed its leaves in the fall?

6. Account for the dry, brittle nature of the stem, twigs, and leaves.

7. Note how the fallen leaves collect at the base and mix

A Sagebrush Plain

with the soil. What effect will this action have, in time, upon the soil of an area covered with a dense growth of sagebrush?

8. Examine the root. As the great number of small root fibers enter the soil and after doing their work die and decay, what effect will they cause in the soil?

9. Study the seeds. What can you say of their size and number? How are they scattered? Do many of them grow?

10. Does sagebrush grow alone or do the plants grow in great numbers together?

11. How do men clear off sagebrush when they wish to

cultivate the soil on which it is found? Why can they burn it off more easily than other shrubs?

The leaves and seeds of sagebrush are often used for medicine, but the plant's greatest good to man is its enriching of the soil.

12. What other plants help to make soil rich?

13. What domestic animal uses sagebrush for food? Because of this it is a great source of wealth to whom?

14. Why are not the great sagebrush covered plains and hills used for a summer range as well as for a winter range?

FOURTH GRADE—WINTER WORK

LESSON XXII

SNOW

1. What conditions indicate the approach of a snow storm? Consider the winds, the clouds, the temperature, etc.

2. When does the first snow usually come in your vicinity? How long does winter last?

3. What determines the length of winter in different parts of our country?

Experiment.—When it snows, watch the flakes as they fall. Catch them on a cold slate or a dark-colored cloth and examine them with a lens, before they melt.

4. Have the flakes any common shape? Examine the largest and most perfect flakes you can catch. Compare them with hoar frost.

5. Tell how they are formed. Draw several different flakes having different forms.

6. Where does most snow fall, in the valleys or on the mountains? Why? Is this a wise provision? Why?

7. Describe how snow accumulates in the mountains.

8. Have you ever seen snow slide off a steep roof? What causes it to do so?

9. Account for snowslides or avalanches in mountainous regions.

10. Where do they often occur? Why?

11. Describe a snowslide. What harm do snowslides often do to people? to railroads? to trees?

12. When does the snow stored in the mountains melt? At what temperature does snow melt?

13. Where does it never melt?

14. Have you ever seen snow in summer?

15. When do the snows in the mountains melt most rapidly? How does this affect the size of the rivers?

16. If all the snow were to melt as soon as warm weather comes, what harm would result?

17. What good comes to us because the great deposits of snow melt slowly during much of the year?

18. What feeds the streams and springs during the summer?

19. In countries where it never snows, they have a wet and a dry season instead of winter and summer. How do you think their streams compare with ours? Why do the people there often suffer for water?

20. Why do the people who live in the arid regions of the United States always like to see an abundance of snow each winter stored in the mountains?

21. Why are most of the towns there situated near high mountains?

22. In time of high water, when the snows melt most rapidly, are the streams clear or muddy?

23. What will be the effect upon the land to irrigate it frequently with this muddy water?

Note.—Irrigated land rarely becomes exhausted. New material is added each time it is irrigated. In fact, often the farmers will turn a large muddy stream of water over a poor piece of land, and, as the water spreads over it and sinks downward into the ground, a layer of the richest soil is deposited on the surface. The author has seen soil eighteen inches deep formed in this way.

LESSON XXIII

PREHENSION OF FOOD

1. Can any animals live long without eating?

2. Mention different kinds of food that are eaten by different animals.

3. What animals live chiefly upon plants? What plants are raised by man chiefly to feed to animals?

4. Animals that live upon plants, or herbs, are called *herbivorous* animals. Make a list of all the *herbivorous* animals that you know.

5. What animals cannot eat vegetation? Which of these live upon the flesh of other animals? Make a list of those you know. These are called *carnivorous* animals.

6. What animals live upon insects? Make a list of *insectivorous* animals.

7. Name animal foods that grow near the ground; that grow on trees; that are found in the water.

8. Do any animals find their food in the mud? What animals catch their food in the air?

9. Mention other places where animals find their food.

10. Describe the different ways that animals have of seizing their food and putting it into their mouths.

11. How does man convey his food to his mouth? Could he feed himself without hands? Describe a babe's efforts in learning to do this.

12. Make a list of all the animals you know that use their hands or fore limbs in the act of eating. Describe their movements in eating.

13. What animals do not use their fore limbs in getting their food? How do they get their food into their mouths? Discuss in detail several common animals in this respect.

14. What does the horse eat when in the wild or natural state? How does he get his food into his mouth? How does a cow do this? What is the shape of the horse's head? Where is his mouth? How does the length of his neck correspond with that of his legs? How do all these things enable the horse to feed? If his legs were as long as those of the giraffe, could he live upon his present kind of food? What would be the result if the horse's neck were as short as the hog's?

15. How does a horse drink? Can you tell how he makes the water run up his neck?

16. Tell in like manner how the following animals get their food and eat it, considering the shape of the head, the mouth parts, the ability to reach and seize food, the kinds of food that they eat, and the places and conditions where each kind is found:—the sheep, the cat, the chicken, the duck, the woodpecker, the toad, the fly, the mosquito, and any other animals that you have seen eating.

17. From what you have seen in the menageries or learned in other ways, tell how the following animals get their food and put it into their mouths:—the elephant, the giraffe, the eagle, the crane, the kingfisher, the alligator, the codfish.

18. Why can sheep "run out" horses and cattle on a range? Which eat the grass off closer to the ground? Why?

19. Could a cat and a rabbit exchange kinds of food and hunting grounds, and survive?

20. Can you think of a wise purpose in nature for having all these different animals made so that each kind gets its food in a different way?

21. Can you tell by an animal's mouth parts anything about the kind of food it eats? Explain.

LESSON XXIV

ADAPTATIONS FOR FOOD GETTING

1. Bring to class the heads and feet of any birds or animals that can be secured without killing them for the purpose. From the fish or game market, specimens may be obtained for study.

2. Study tame animals at home or stuffed specimens at school to learn of the ways in which different animals are adapted to get their food.

Suppose we study the duck and the owl from the samples.

3. What is the food of the wild duck? Where is this food found?

4. How is a duck's bill adapted to scoop up insect food found in the mud? Examine carefully the duck's mouth.

5. What is the use of the saw-like teeth? Are they fitted to

chew food? Have you ever heard a duck "smack his lips" after probing in the mud for a time? He seems to be washing the mud out of his mouth and straining the water through his teeth, that the *larvæ*, or insects, caught in the mud may not escape.

6. Why does not water wet the duck's feathers? Compare them with the feathers of the owl. Have you seen ducks preening their feathers? They cover them with oil which makes them waterproof.

7. Do ducks make much noise in flight? Would a noise frighten away their food? Is the color of the duck's feathers of any advantage?

8. Describe the duck's feet. How do they aid the duck when hunting for food? Can the duck see when his head is under water?

9. Why is his body boat-shaped? Why are the legs so short and placed so far toward the rear of the body?

10. Compare the movements of a duck on land, in water, and in the air.

11. Why do ducks need to swim and dive well? Do they spend much time on the land? Why are ducks good flyers?

12. Do wild ducks migrate? How and where do they rear their young?

13. Are they ever hunted for sport? During what months? Why?

14. Tell what you know of the habits of tame ducks. What do they eat?

15. Is the owl a useful or a harmful bird? What is his food?

16. When does the owl search for his food? Describe his eyes.

17. Describe the beak of the owl. How is it adapted to aid him in getting his food?

18. Describe the owl's feathers. Why are they so soft and fluffy? Is his flight noisy or silent? How does this aid him in getting his food?

19. Is the owl's color any advantage?

20. Tell how the owl's feet help him in securing his prey. Would the duck's feet serve the owl's needs?

21. How may the head and feet of a bird tell us what he eats?

22. Examine all the specimens before the class, and tell what kind of food each animal eats as shown by its mouth parts, its feet, and other parts of its body.

LESSON XXV

THE SKELETON

1. What animals have soft, fleshy bodies without any bones? Make a list of all such animals that you know.

2. Describe their movements. Do they run fast or crawl slowly? Do any of them fly? Do any swim? How do they contrive to move?

3. What animals have a hard, bony covering on the outside? Make a list of those that you know. Are their movements quick or slow? Describe the movements of several of them.

4. What animals have a bony skeleton within their bodies? Make a list of those that you know. Compare their movements with those of the other two kinds. How do these animals contrive to move?

Experiment 1.—Bend your arm slowly at the elbow, and answer the following questions from your own observations:

5. What muscle makes the arm bend at the elbow? We call this the *biceps* muscle. How does this muscle act to cause this motion? If there were no bones in the forearm, could the movement be made in this way? How are the bones of the forearm joined to the one in the upper arm? This kind of joint is called a *hinge* joint. Why is it so called? Could this motion be made if there were no joint at the elbow? Does the biceps muscle have to shorten much to move the hand as far as it can go? Explain why this is. What muscle straightens the arm? It is called the *triceps* muscle. Describe its action.

6. How many movements can be made with a hinge joint?

7. Are all the joints hinge joints? Name all the hinge joints that you can find in your body.

8. How many kinds of movements can be made at the shoulder? Is this a hinge joint?

Movement in many directions is secured by a *ball and socket* joint. The upper end of the arm bone is round like a ball, and fits into a socket in the end of the shoulder blade.

9. Can you find another ball and socket joint in your body?

10. What kind of joints have we at the knee? at the wrist? at the hip? at the knuckles?

11. How do the bones aid in the movements at these joints?

12. Do swift animals have long and slim bones, or short and thick ones? Why? Compare a race horse with a draft horse; a deer with an ox; a hawk with a hen.

13. Are all the bones in the body used in causing motion? What is the use of the bones of the skull? of the ribs? of the bones of the face? of the backbone? How many different uses have the bones of our bodies?

Experiment 2.—Place a slender bone in weak muriatic acid and another in a hot fire for a time, and note the effects. The acid will dissolve the lime, or mineral matter, out of one bone, and the fire will burn all the gristle, or animal matter, out of the other. The first can then be bent or even tied in a knot, while the latter is very brittle.

14. Why may a child fall many times without breaking a bone, while an aged person is so apt to break one in falling?

15. Why do bones need to be tough in childhood and rigid in old age? What gives toughness to the bones? What makes them hard and rigid?

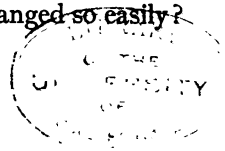
16. At what time in life are bones most easily bent and made to grow in a wrong shape? Would it injure an old person as much as it would a young child to sit long in a wrong position?

17. Should a baby be urged to walk when very young? Why not? Should small children in school sit on a seat so high that their feet will dangle? What may result from this error in time?

18. What will be the result if children wear shoes or clothes that are too tight? How are the feet of Chinese women deformed? Could this be done in old age? Why?

Some savage tribes think a flat forehead and a sloping head beautiful, and place their infants' heads in an angle between two boards that are fastened together at one end, in such a way as to flatten the forehead and back of the head, making a sharp point or edge at the crown.

19. Could the shape of a man's head be changed so easily?



LESSON XXVI

HEAT—TEMPERATURE SENSE

Experiment.—Get three vessels of water—one very cold, one very warm, and one temperate (about 70°). Place the right hand in the warm water and the left hand in the cold water. Keep them there for a few minutes.

Take the hand from the warm water and place it quickly into the temperate water. How does the latter feel to it? Next take the other hand from the cold water and place it in the temperate water. How does it feel to this hand?

1. One hand says that the temperate water is cold; the other hand says that it is warm. Which hand tells the truth? Explain.

2. Notice carefully what takes place with each hand during this experiment. When the hand was placed in the hot water, what happened to the heat in that hand? When it was taken from the hot water and placed in the temperate water, did it lose or gain heat? Did the other hand lose or gain heat when placed in the ice water? in the temperate water?

3. When heat is going out of our bodies, how do we feel? When it is entering our bodies, how do we feel?

4. How might a good closed barn feel to a man who had ridden a long distance in a blizzard? How would the same barn feel to a man who had just left a warm fire?

5. Give other examples where the same temperature might be described as both cold and warm.

6. Can we always judge temperature accurately? What instrument do we use to do this?

LESSON XXVII

HEAT—SENSE TRAINING

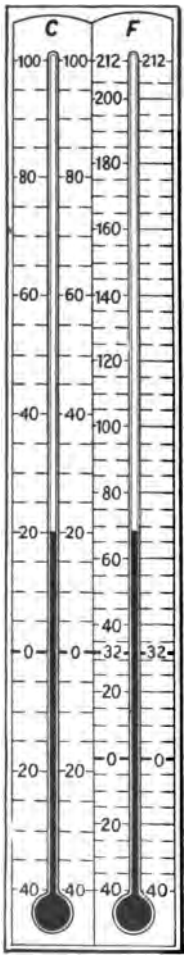
To THE TEACHER.—Perform the following experiment in the class and continue as long as necessary the training of the temperature sense. It will soon become quite accurate.

Let the pupils feel and judge the temperature of a vessel of water 150° F. Add cold water until it is 130° F. and let them judge again. Continue reducing the temperature 20° at a time, letting the pupils feel of it and judge each time, verifying each judgment with a thermometer.

In like manner begin with ice water and raise its temperature 20° at a time by adding boiling water. Let the pupils feel and judge the temperature each time and verify as before.

Repeat the experiment each day for a time, first changing the temperature only 10° at a time, then only 5°; until the pupils learn to judge with considerable accuracy the temperature of liquids.

1. Of what value is our temperature sense to us?
2. In what ways does it guard our health? our life?
3. From what injuries does it keep us?
4. What things might we swallow or handle that would do us harm but for the pain they cause by burning us?
5. In what ways is a well-trained temperature sense useful in cooking? in other kinds of housework?
6. How is this sense useful to the physician?
7. What tradesmen need it in their work?
8. Judge the temperature of the air each time before you look at the thermometer, and learn to tell how cold or warm it is by your own feelings.
9. Which was colder, yesterday or to-day? this week or last, and how much? After judging, look at your record and see how nearly correct you are.



LESSON XXVIII

HEAT—MEASUREMENTS

1. Why do we need a thermometer in the schoolroom?

2. For what does a doctor use one?

3. Why do men sometimes hang thermometers among the trees of their orchards?

4. Did you ever use a thermometer in making candy?

5. Tell as many uses as you can of the thermometer and why one is needed in each case.

Experiment.—Breathe upon the bulb of a thermometer, and note what happens. Why does the mercury rise? Place the bulb in cold water. What happens? Explain the action of the thermometer.

6. What other things have we studied that expand with heat and grow smaller with cold?

7. Study the scale on the thermometer. Where is freezing point? blood heat? boiling point? How can you test if these points are correct?

About two centuries ago, a German named Farenheit invented the thermometer most commonly used. He marked the freezing point of ice 32° above 0, thinking that there was no heat below 0. The temperature of our blood he made 98°, and that of boiling water, 212°. Many cheap thermometers are not made to test the boiling point.

Another method of marking the same temperatures is used in the Centigrade thermometer, which is much easier. The temperature of melting ice is marked 0, and that of boiling water, 100°. These two natural points are easily tested.

8. From the illustration learn to compare the two gradings. How many degrees are there between freezing point and boiling point in the F. thermometer? in the C. thermometer?

9. Which is greater, one degree C. or one degree F.? How much?

LESSON XXIX

HEAT—NATURAL SOURCES

1. Where does the earth get most of its heat?

2. Do we get the same amount of heat from the sun at all times? What parts of the day are coldest? warmest?

3. What part of the year is warmest? coldest?

4. From what you have already learned, can you give any reasons for the changes in the amount of heat that we get from the sun at different times?

5. Do we get any heat from the moon? from the stars?

6. Where does the snow melt first—on a mountain, or in a valley? Why is there so much more snow on a mountain than in the valley?

7. Why do many people spend the hottest weeks in summer at some mountain resort?

8. What changes in temperature do balloonists tell us take place as they rise higher and higher?

The heat of the sun strikes the earth and collects near its

surface very much the same as it collects and warms the air on the sunny side of a building in the winter. The further we go from the surface that reflects the heat, the colder it becomes.

9. State one reason, then, why hills and mountains, being above the general surface of the earth, are cooler than the the lower places?

10. Would the thin air of the upper regions hold warmth as well as the heavier air near the ground?

11. If you lived by the sea and near where a great current of warm water coming from near the equator flows, how do you think that this current might influence the temperature near your home?

The gulf stream is such a current and makes some countries much warmer than they would be without it.

12. Do winds influence temperature? What winds near your home are generally cold? which are warm?

11. Are some soils warmer than others?

Experiment.—Take a chalk box filled with sand and another filled with clay dust, and place them in the sun. Both should have the same temperature at first. Test them at intervals with a thermometer.

12. Which draws more heat from the sun, sand or clay?

13. Explain the expressions "burning sands" and "as cold as clay."

14. Why are some soils spoken of as "warm soils?" Which will produce the earlier radishes, sandy soil or clayey soil? Which kind of soil would a market gardener prefer?

15. Mention all the things you can that influence temperature.

LESSON XXX

HEAT—COMBUSTION

1. Does the sun furnish us with all the heat that we need? For what purposes do we need more heat than the sun gives us? How do we make heat for these needs?

2. What things are used for fuel? Bring for the school cabinet samples of fuel—coal, coke, wood, charcoal, peat, etc.

In some places gas and crude petroleum are used for fuel. Gasoline and alcohol also are sometimes burned to make heat.

3. Which is the most common fuel? Where does the coal burned in your city come from? What does it cost a ton?

4. Which makes more heat, wood or coal? Which costs more?

5. Describe making a fire. How is it regulated?

6. Name all the parts of a common stove. (Recall the work of Lesson 29, Third Grade.)

7. What is needed for a fire besides fuel?

8. Mention all the different kinds of fuel that you know; describe each kind and tell for what it is used.

9. In what two ways may we fix the amount of heat from a stove or furnace? If the fire becomes too hot, what do we do? Why? When it is too low, what do we do? Why?

10. How do Indians and other savage tribes make and use fire? What fuels do they use?

11. Which have greater need for heat, civilized or savage people?

12. Tell many things that we do with artificial heat.

13. Visit a blacksmith shop, a foundry, a smelter, or other places where great heat is used.

14. Describe the manner of heating the school building.

LESSON XXXI

HEAT—RELATION TO OXYGEN

Experiment.—Pour some limewater into a wide-mouthed bottle and shake it. Do you see any change in the water? Now carefully lower a piece of lighted candle into the bottle by means of a wire wrapped around it. Cover the mouth of the bottle with the hand until the light goes out. Remove the candle and shake the water again for a few moments.

1. How has the water changed? Why did it not turn milky before?

2. Has the appearance of the air in the bottle changed?

Note.—This test shows that after the candle went out, the air in the bottle contained something that it did not contain before—a gas called *carbon dioxide.* This gas is made whenever common fuels are burned. We cannot see it nor smell it, but its power to turn limewater milky is a good means to find out when it is present.

3. Why did the candle go out?

4. Would it have gone out if it had been supplied with a current of fresh air?

5. What becomes of the carbon dioxide made in stoves, grates, etc.? What would be the effect if this gas were not taken out of our rooms?

Note.—Carbon dioxide is made of one part of carbon obtained from the fuel and two parts of oxygen obtained from the air. The union of these two elements produces the heat caused by the fire.

6. What will happen to a fire, then, if the supply of either of these two elements is cut off?

7. Why should the doors and windows of a burning building (except those used by the firemen) be kept closed?

8. Why may a fire, just starting, be "smothered" by putting over it a quilt, blanket, overcoat, or other covering that may be at hand?

9. Explain "banking" the fire in a furnace.

10. Will too much fuel ever put out a fire? Will too much air ever put out a flame? Why?

11. What condition is necessary before fuel and air will unite so as to make a fire and produce heat? Explain how a fire is started.

LESSON XXXII

HEAT—FRICTION

Experiment.—Rub a brass button upon the sleeve or upon the floor. A stick rubbed with hard pressure in a close-fitting groove will serve the purpose better.

1. What causes the heat produced?

2. Mention examples of heat being made by rubbing things together. Did you ever see an axle of a wagon get hot because someone had forgotten to oil it?

3. Explain the striking of a match; the "hot box" on a train; the sparks that fly from the brake blocks when a train is being stopped quickly.

4. Is the heat produced by friction ever used by man? Give examples.

5. Is it ever harmful to man? Give an example.

6. How is friction prevented in machinery? Explain the use of lubricating oil.

7. Compare the friction of ball bearings with that of other kinds of bearings.

8. Why do we rub our hands together briskly when they are cold?

9. Explain why the iron break-blocks on heavy freight-cars often get red hot while going down the steep slopes of the Rocky Mountains.

LESSON XXXIII

HEAT—PERCUSSION

Experiment.—Hammer vigorously a penny, or any small, thin piece of metal, on an anvil or large stone. Note the heat produced. Blacksmiths often make iron very hot in this way.

1. Have you ever made sparks by striking together two large stones?

2. Explain the old-fashioned way of making a fire with flint and steel. Explain the firing of an old flintlock gun.

3. How is a modern gun fired? How is the heat needed to burn the powder produced?

4. Give other examples where heat is produced by a blow or shock. Does man often use this method in making heat? How was fire made before we had matches?

A pound weight, falling a distance of 772 feet, will make enough heat on striking to raise the temperature of a pound of water one degree.

5. Niagara Falls are 160 feet high. Is there any difference in the temperature of the water at the top and the bottom of the falls? Why?

6. Does "whipping" cream or "beating" eggs change their temperature? Why?

LESSON XXXIV

HEAT—ELECTRICITY

Experiment.—Turn on the electric light and feel the bulb gradually get warm. What makes the heat?

1. Mention other examples of heat coming from electricity. Describe electrical heaters, stoves, flatirons, etc.

2. Are the wires that carry the electricity always hot?

Electricity is turned into heat when it is forced to pass through a wire or other medium that is too small or that resists its passage.

3. Have you ever seen a small wire melted when a large one carrying electricity broke and fell across it?

4. Lightning is electricity. Have you ever heard of houses, barns, oil tanks, etc., being set on fire by lightning?

5. Tell of any accidental burnings that you may know of that were caused by electricity.

In foundries and other places where steel and iron are made or used, workmen often cut or weld great steel bars by means of heat from an electric current.

6. What marks of heat have you seen on trees or other objects that have been struck by lightning?

7. When persons are killed by lightning, does it ever burn them?

8. Examine the "fuse" in a common electric light. Why is it made of lead?

9. If lightning strikes the electric wires, how does the "fuse" protect our home?

LESSON XXXV

HEAT—CHEMICAL ACTION

Experiment 1.—Pour some cold water on a little quicklime and watch the action that takes place in a short time.

1. What change takes place in the temperature of the lime? in the form or condition of the lime?

Experiment 2.—Pour a few drops of sulphuric acid into a little cold water in a test tube, and feel the water grow warmer.

2. Can you tell why it gets warmer?

Experiment 3.—Pour a few drops of the same acid into a mixture of sugar and potassic chlorate. A fire is produced at once.

When great changes take place rapidly from putting together two or more substances, heat is often produced. This change is called *chemical action,* and often takes place so slowly that little or no heat is made.

3. When hay is put into the stack or barn before it gets dry, why does it "heat" and turn black and musty?

4. Account for the steaming of a damp manure pile and its heat, which often melts the snow as fast as it falls upon it.

Decay is a chemical action and when rapid often creates heat.

5. Have you ever heard of a barn or store burning from this cause?

6. Have you ever seen a pile of damp clothes that had become warm after lying for a long time without being moved? Give examples of heat caused by decay, molding, or by other chemical action.

LESSON XXXVI

HEAT—EXPANSION OF SOLIDS

Experiment 1.—Take a small round bottle and twist a fine wire around it so tightly that the loop will hold up the bottle. Now remove the loop and heat it red hot in the lamp flame and it will allow the bottle to slide through it with ease while the wire remains hot.

1. Explain the action of heat in this experiment. Give other examples where you have seen heat cause solids to expand.

2. How are wagon tires "set" by blacksmiths?

3. Why do we heat the neck of a bottle when the glass stopper refuses to come out?

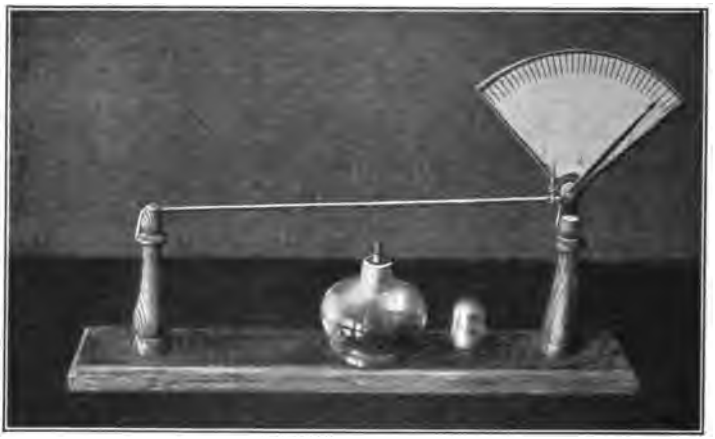
4. Why is a small space left between the ends of rails on a railroad track? Think of other examples of this law.

5. The author once saw a railroad station burned. During the fire the tracks in front of the burning building rose gradually many feet into the air. What do you think caused them to do this?

6. How may the amount of expansion of a solid by heat be measured? Study carefully the piece of apparatus shown on the next page and make one like it in the manual training room.

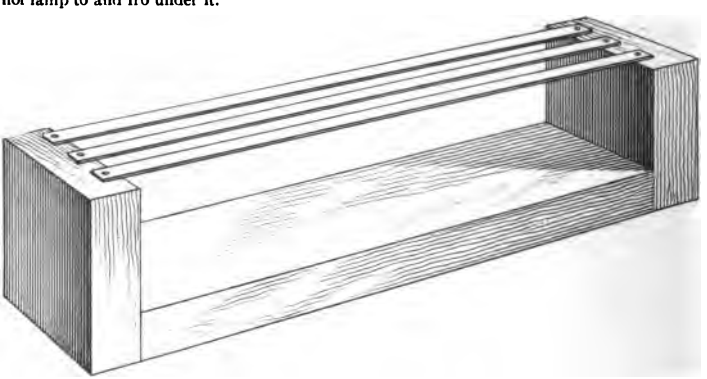
7. How will the expansion of the wire move the short end of the index finger? How will it move the long end? How will the distance one moves compare with that of the other?

8. Suppose the short end of the index finger is half an inch and the other five inches long, how will their respective movements compare? How will this tell us the amount the wire has lengthened?



MEASURING EXPANSION DUE TO HEAT

A heavy, horizontal wire is fastened at one end to an upright post, and passes through a loop at the other end, where it presses against the short end of an index finger. The long end of the finger moves over a graduated arc. The wire may be heated by moving an alcohol lamp to and fro under it.



Experiment 2.—Fasten firmly to a strong frame, as shown in the cut, several strips of different metals as iron, copper, zinc, etc. Place them on a hot radiator or stove, or in a vessel of boiling water, in such a way that all the strips will receive the same amount of heat.

9. Do you think the same amount of heat will expand all metals equally?

10. What change does the heat produce in the strips? Explain it.

11. Which metal expands most?

LESSON XXXVII

HEAT—EXPANSION OF LIQUIDS AND GASES

Experiment 1.—Fill a Florence flask full of water and close the mouth with a cork through which passes a long glass tube. Heat the water in the flask and it will begin to rise in the tube, and may be made to overflow.

1. What effect has the heat upon the volume of water in the flask?

2. Recall the action of the thermometer and its causes.

3. Why does a teakettle boil over?

4. Think of other examples where heat causes liquids to expand.

Experiment 2.—Arrange an empty flask as in the last experiment, but with the upper end of the glass tube bent and placed under water. Apply heat and notice the bubbles of air leaving the flask. Remove the heat, and, as the flask cools, observe that the water will be sucked back into it.

5. Explain the effect of heat in this experiment. Can you think of any use that is made of this principle?

Experiment 3 (for the teacher).—Take a piece of small glass tubing about two inches long and close one end by heating it in the alcohol lamp. When cold, pour a few drops of water into the tube and seal the other end in the same way, taking care to hold it so that the water will remain away from the end while being heated. Suspend the tube in

the flame of the lamp and place a pane of glass between it and the class. In a few minutes the tube will burst with a loud report and small pieces of glass will be thrown in all directions.

6. Explain the action of the heat in this experiment.

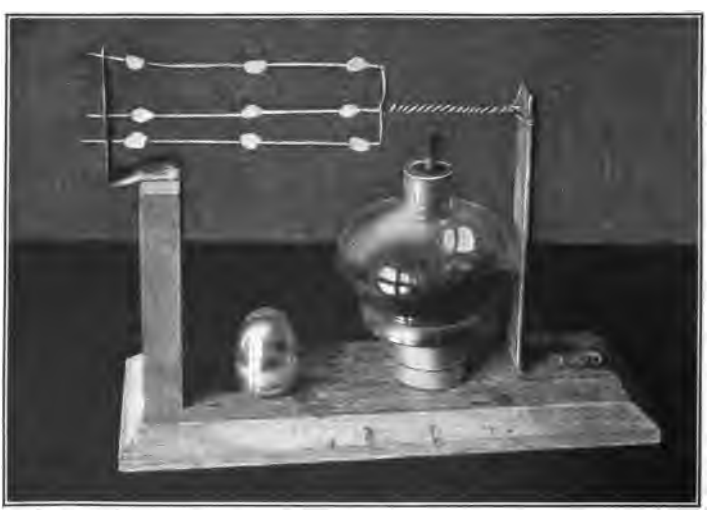
7. What use is made of this great expansive force of steam? What dangers does it often cause?

8. What actions in nature are no doubt due to this cause?

LESSON XXXVIII

HEAT—CONDUCTION

Experiment 1.—Take three wires of equal size—one of iron, one of brass, and the other of copper—and twist them together at one end into



a common stem. Separate the other ends and fasten them as shown in the illustration.

On each wire, at equal distances from the stem, place small balls of wax. Now heat the stem and note the order in which the wax balls melt.

1. Where does the heat come from that melts the balls?

2. Through what does the heat travel to reach the balls? How do you know that the heat does not travel through the air?

3. Which ball melted first? second? third? What effect had the distance of the ball from the heat upon its time of melting?

4. Why did not all the balls that were the same distance from the flame melt at the same time?

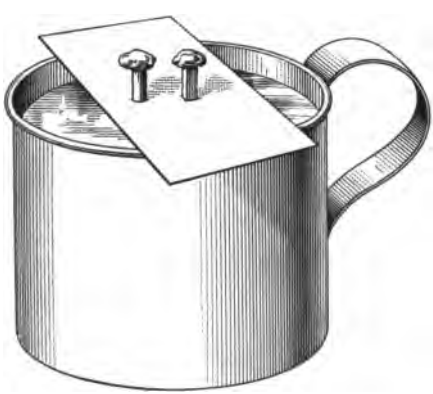
5. Which wire carried (*conducted*) the heat fastest?

6. The heat traveled slowest in which wire?

That which carries, or conducts, heat fast is called a good *conductor* of heat. What would be a poor conductor?

7. Which of the three wires is the best conductor of heat? Which is the poorest conductor?

8. Are all solids conductors of heat?



Experiment 2.—Pierce a card with a wire nail and a splint of wood of the same size and length. Lay the card over a cup of boiling water so that the greater length of the nail and the splint will be in the water. Place a wax ball on the upper end of each and note which ball will begin to melt first.

9. How do wood and iron compare as conductors of heat? Why is wood called a *non-conductor* of heat?

10. Mention good conductors of heat. Make a list of them. Name as many uses of good conductors as you can.

11. Mention some poor conductors of heat. Make a list of them.

12. Why are handles of pokers, oven doors, teakettles, flat-irons, etc., made of wood or of coiled wire?

13. Would a lumber box filled with hot water or steam serve to heat a room as well as an iron radiator? Why?

14. Why are steam boilers and pipes often covered with asbestos?

Experiment 3.—Make two snowballs of equal size. Wrap one of them in cotton cloth and the other in woolen cloth of the same thickness. Put them both on the radiator, or in some warm place side by side, and see which will melt first.

15. Which is the better conductor of heat, wool or cotton? Why?

16. Which is used more in winter clothing? for summer wear?

17. Explain how our winter animals are kept warm by the coats nature gives them.

LESSON XXXIX

HEAT—PHYSICAL CHANGES

Heat is a wonderful power and brings about many strange results when used upon different things. Mention as many

different effects of heat upon different things as you can. Here are a few:

I—Heat Softens

1. What things are softened by heat? Which get soft by gentle heat? Which take a great amount of heat to soften?

2. What use does the blacksmith make of this law of heat?

3. What things in our homes do we make soft with heat? What is the effect of heat upon most of our foods?

4. Is this action of heat ever harmful to us? Is any thing ever damaged by it?

II—Heat Melts

1. Make a list of things that will melt when heated.

2. Which of these things will melt if left in the sun?

3. Which will take the heat of a furnace to melt them?

4. Do you know of any solids that cannot be melted? Name some.

5. Name many ways in which this power of heat is used.

6. What things sometimes melt when we do not want them to melt?

III—Heat Vaporizes

1. What becomes of water spilt on a hot stove? Does water ever disappear with gentler heat?

2. What other things are turned to vapor by heat? Make a list of these.

3. What is the most important use made by man of this power of heat?

Most of the coal burned in the world is used to make steam.

4. What accidents sometimes happen from vapor caused by heat?

5. Does heat ever turn things to vapor to man's injury?

IV—Heat Toughens

1. Mention things that are made tougher by heat.

2. Compare burned and unburned bricks. Which are tougher?

3. How is glass annealed, or made so it will not break easily?

4. How is iron made into steel?

V—Heat Hardens

1. Give examples of the hardening effects of heat.

2. What foods get hard with too much cooking?

3. Why is pottery ware burned?

4. Is heat used in tempering steel?

5. How is the hard glazing put on earthenware?

6. Mention any other uses of heat in the kitchen; in the laundry; in the factory; in the foundry; in the garden; in the field, the forest.

LESSON XL

EVAPORATION

To the Teacher.—Preparing the experiments may take the entire time of the first recitation period. Several lessons may then be given in considering the results of the experiments, making inferences, and applying the principles discovered.

1. Why does a teakettle boil dry? What becomes of the water?

2. Explain the drying of muddy roads; of sprinkled streets; of wet clothing on the line.

Experiment 1.—Put equal quantities of water into two similar vessels; place one of these in a cool place and the other upon the stove or radiator. Allow them to remain there several hours.

3. Which vessel has lost the more water? Why?

4. Give several examples of evaporation caused by heat.

5. How do we use heat to dry things in our homes?

6. How are clothes dried at the laundry?

7. Give examples of heat used to hasten evaporation in manufacturing and other industries.

8. Compare the moisture seen in nature in cold and in hot weather. When are the roads muddy? When are they dusty? When do weeds and grass die of drought? When does the dew on the grass disappear? Why?

9. When is evaporation a good thing? When does it do harm?

Experiment 2.—Place two equal vessels of water where they will have the same temperature, covering one so that the air cannot reach it, and exposing the other to air currents.

10. In which vessel is evaporation most rapid? Why?

11. Why do we wave a wet handkerchief when we are trying to dry it? Do clothes on the line dry on a calm day as fast as they do in the wind?

12. What effect has the wind upon muddy roads?

13. In the arid regions, why do the farmers dislike a wind just after irrigating their crops?

14. What is the effect of the wind upon our hands and faces if we are out in it long? (See Lesson 28, Third Grade.)

15 Give other examples of air currents causing evaporation.

Experiment 3.—Place the same amount of water in each of two vessels, one being shallow, like a saucer, exposing a large surface to the air, and the other narrow and deep, exposing only a small surface to the air. Keep both at the same temperature and note from which the evaporation will be the more rapid.

16. What effect has the amount of surface exposed to the air upon the rate of evaporation?

17. Why are wet clothes hung on a line?

18. Why is hay allowed to lie several days after being cut before it is raked and piled and placed in a stack or a barn?

19. Why are haycocks often scattered after a rain?

20. Why are bottles containing liquids generally corked?

21. What three conditions hasten evaporation?

22. Describe many examples of where one or more of these three conditions are used to cause evaporation.

23. Describe a fruit evaporator and explain how it works.

24. What things do we keep moist by preventing evaporation? Give examples.

25. When plants are suffering for water, what is gained by the leaves curling together?

LESSON XLI

EVAPORATION—(Continued)

1. Do other liquids than water evaporate? Mention some that do.

2. What liquids evaporate rapidly?

3. Which evaporate slowly or not at all?

4. Do any solids evaporate, or decrease in size and weight, when left exposed to the air or sunshine? Give examples.

5. Is this shrinkage due to the evaporation of water contained in the solid, or does the solid itself disappear?

6. If these solids are put in a damp place, will they regain any of their lost size or weight?

Note.—Few solids evaporate. Most of them contain water which may be drawn off by heat, etc., leaving them smaller and lighter, but they never dry away entirely as do most liquids.

7. Does ice or snow ever disappear without melting first? Do clothes frozen on the line ever dry without thawing first?

Experiment.—Put equal quantities of water, alcohol, turpentine petroleum, honey, oils of various kinds, or any other liquids easily obtained, into vessels where conditions for influencing evaporation will be equal, and find out their difference in rate of evaporation. A drop of each liquid placed on a clean pane of glass to evaporate will serve the purpose fairly well.

8. Make a list of the liquids tested, writing first the ones that evaporate most rapidly.

9. Which would dry first, a coat of paint or varnish mixed with alcohol, or with turpentine, or with linseed oil? Why?

10. Why do painters call turpentine or alcohol a "dryer?"

11. Would oils that evaporate be good to use in oiling machinery? Why?

12. If water and alcohol are mixed and gently heated, which will pass off as vapor first? Why?

13. In roasting meats, how do we prevent the juices from evaporating?

14. Why is perfume kept in bottles having ground glass stoppers?

15. What liquids are valuable because they evaporate quickly?

16. What liquids are valuable because they do not evaporate quickly?

LESSON XLII

CONDENSATION

Experiment 1.—Hold a slate or any cold surface in the steam of a tea kettle, or breathe, upon a cold window pane.

1. What do you observe on the cold surface?

2. Where does it come from?

3. What change takes place in the temperature of the vapor as it touches the cold surface?

4. Why does a pitcher of ice water "sweat" after standing for a while in a warm room?

5. Observe carefully the stream of vapor as it issues from the teakettle, and note that it cannot be seen at the mouth but becomes visible a short distance from it. Why is this?

Experiment 2.—Place the flame of an alcohol lamp in the visible steam and explain why the steam becomes invisible at that point.

6. What change takes place in the temperature of the vapor as it mingles with the air? as it touches a cold surface? as the flame touches it?

7. Account for the moisture often seen on window panes in the winter. Why is it not seen there so often in summer?

8. If this moisture on the window should freeze, as

it *condenses* there, what would be formed on the window?

9. On which side of the window is the frost formed? Why?

10. In the summer time, which gets cold first after the sun sets, stones, earth, etc., or grass and other plants? Explain how dew may be formed and on what things it is formed.

11. If dew should freeze as fast as it gathers, what would be formed?

12. Apply the thought in this lesson to the formation of clouds; of rain; of fog; of mist.

13. Mention many examples of *condensation* and its uses in nature and to man.

LESSON XLIII

WORK FOR THE FROST

1. When water freezes, where are the first ice crystals formed? Examine some with a lens and describe them.

2. Show by means of a drawing how they form a network on the surface until a crust of ice is made.

3. Why does ice form on the surface of water?

4. What makes it float? About what part of a piece of ice will remain above the surface? Test it.

5. What would be some of the results if ice were heavier than water?

6. What happens to a pitcher when water freezes in it?

7. What causes water pipes to burst sometimes in very cold weather?

8. What do these things tell us about the space a given amount of water occupies before and after freezing?

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9. Is this an explanation of why ice floats on water?

10. Why are water mains laid about four feet deep in the ground?

11. How deep does the prairie dog dig his winter home?

Experiment.—Dig holes in the frozen ground in several places and find out how deep the frost penetrates in the different kinds of soil and report in the class.

12. In what kinds of soil does the frost go deepest?

13. When the frost comes out of the ground in the spring, in what condition does it leave the soil?

14. Why is frost sometimes called "nature's plowman?"

15. When does the farmer do most of his plowing? Is the ground as easily plowed at other seasons as in the spring?

16. Compare the work of digging in the garden at different seasons of the year. When is it easiest? Why?

17. What plants are liable to be hurt by late frosts in the spring? How may they be protected?

18. Why are tomato and cabbage plants often started in a greenhouse and afterward transplanted to the garden, especially in the northern states?

19. What fruit crops are sometimes killed by untimely frosts?

20. Discuss the good and bad effects of frost upon various things, and methods used to keep it from doing damage.

FOURTH GRADE—SPRING WORK

The year's at the spring
And day's at the morn;
Morning's at seven;
The hillside's dew-pearled;
The lark's on the wing;
The snail's on the thorn;
God's in his heaven—
All's right with the world!
—ROBERT BROWNING.

LESSON XLIV

THE WEATHERING OF ROCKS

1. If the frost softens and loosens the soil, does it have any effect upon the rocks?

2. Have you ever seen stone doorsteps, window sills, or copings that seemed to be scaling or softening on the outside? Where? Account for the change noted.

3. Strike with a hammer any stone that has been exposed many years to the weather. Does the outer layer seem to be as hard as the inner part?

4. When on a field trip, notice whether large rocks show any effects of the action of weather upon them, and report observations.

Experiment.—Weigh carefully a piece of dry sandstone. Soak it in water over night and account for any change in its weight. Examine the wet stone with a lens.

5. What effect upon the grains of sand in it, would you expect if this stone were frozen?

6. If water, in freezing, expands so as to burst a water pitcher or an iron pipe, how will it act among the grains of sand forming the sandstone?

7. How in nature may stones become wet in the daytime and freeze at night?

8. What effect will this *weathering* of rocks have upon the shape of cliffs and mountain peaks, as it keeps on for ages?

9. Why have the stone pyramids kept their shape for so many centuries in the deserts of Egypt?

10. What becomes of the sand and dirt thus torn loose by the action of weather?

11. When are our streams muddiest? Why?

12. When the snows on the mountain sides melt during the day and fill with water the crevices in the rocks, what will happen when this water freezes at night?

13. Where do the sharp cornered bits of stone come from that are found near the base of most mountain cliffs? How do they get there?

LESSON XLV

EROSION OF ROCKS

Experiment.—Nearly fill a strong bottle with pebbles that have been washed perfectly clean. Add clear water to cover them. Cork tightly and shake vigorously before the class for one minute by the watch. The water will then be quite muddy, unless the pebbles are very hard.

1. What made the water muddy or *turbid*? Where did the dirt in it come from?

2. How may we find out just how much dirt was worn off in one minute by the pebbles rubbing against each other?

Complete the experiment by passing the water through a filter paper, that has been carefully weighed. Then dry it and weigh it again to find how much dirt it has caught.

3. What would be the condition of the water if the shaking were continued an hour? a day? What effect would it have upon the pebbles?

4. Are rocks ever ground in nature in a similar way?

5. What proof of such wearing, or *erosion*, have we in the shape of most pebbles?

Note.—Some of the toy marbles used by the boys in their play each spring are made from stones in a marble mill. The stones are first broken into small cubes and a quantity of them placed in a steel cylinder, which is made to revolve on its axis day and night while a small stream of water passes in and out again. In this manner the edges and corners are gradually worn away and the cubes become spheres. When polished, they are ready for market.

A miniature mill of this kind may be made by using a large glass bottle to contain the pebbles and attaching it to a small water wheel in such a way that it will revolve by the force of the water from the faucet at the sink.

LESSON XLVI

CONSTITUENTS OF SOIL

1. Examine, with a lens, samples of different kinds of soil.

2. Do all the particles seem to be of the same kind of material? Describe them as to shape, size, color, kinds, etc.

3. Which do you think are good soils? Which are poor? Give reasons for your judgment.

4. Can you think of a way of separating the different kinds of materials, or the *constituents*, that make up the soils?

5. How can we get rid of the sticks, leaves, etc.—the vegetable matter?

Experiment 1—Weigh four ounces or 100 grams of good soil that has been thoroughly dried. If possible, heat it red hot in some suitable vessel. Cool it and weigh again. The loss in weight will be the vegetable matter burned in heating it.

6. Are all the remaining particles of the same size?

7. How may these be separated?

FOURTH GRADE PUPILS ANALYZING SOIL—UTAH STATE NORMAL TRAINING SCHOOL

Experiment 2.—Pass the sample through a sieve made of ordinary screen wire. (See Book I, page 161.) This will take out the gravel. Weigh it carefully. Pass the remainder through a sieve made of fine brass wire cloth. This will separate the coarse sand. Weigh this also.

Put the fine dust remaining into a beaker, and wash it very carefully until the water becomes clear. In changing the water, let the fine sand

settle each time before pouring off the turbid water which takes away the clay. Drain off the water when it becomes clear, and dry and weigh the fine sand left in the bottom of the beaker.

8. How may the weight of the clay be found?

9. Compare the amount of clay and sand; of gravel and fine sand. Write the results of this experiment.

10. Which of the samples of soil has most sand? Which has most clay?

11. Where does the soil get its gravel? its sand? its clay?

12. How do leaves and sticks get mixed with it?

LESSON XLVII

NATURE OF SOIL MATERIALS

Experiment 1.—Take three chalk boxes and fill one with sand, one with clay, and one with good garden loam, all having the same temperature. Place them side by side in the sunshine, and test the temperature of each at intervals.

1. Which absorbs heat most rapidly from the sun?

2. Which absorbs least?

3. Do plants grow best in warm or cold soils?

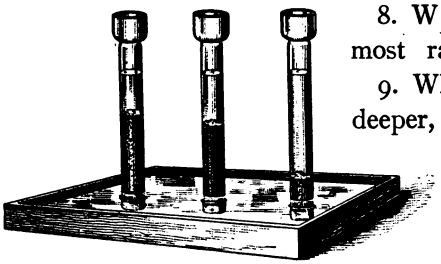
4. The sand in the soil has what influence upon its heat?

5. Does the sand add to the heat of the desert?

6. For early gardening would you prefer a sandy or a clayey soil? Why?

7. Which are called "warm" soils? Why?

Experiment 2.—Take several lamp chimneys and tie a piece of muslin over their ends to retain their contents. Fill one with sand, one with clay, and one with loam. Various samples of soil may be tested at the same time. Stand them upright in a pan containing half an inch of water. (See Illustration, page 82.)



EXPERIMENT 2

8. Which absorbs water most rapidly? most slowly?

9. Where will rain penetrate deeper, in sandy or clayey soil? Which will cause the rain to run off?

10. Why are sand and gravel used on walks and roads to prevent mud?

11. What two things, needed by plants, does sand absorb into the soil?

Experiment 3.—Place like amounts of wet sand and wet clay in the sun, or upon a warm stove, and see which will dry first.

12. The power of clay to retain moisture is of what value to soil?

13. Why does good soil need to have nearly equal amounts of sand and clay? What good does each do?

14. What is the result if the soil has too much sand? too much clay?

15. Can you tell good soils by their looks?

LESSON XLVIII

THE SCHOOL GARDEN

TO THE TEACHER.—Since most schools close by the first of June for a long vacation, a school garden can never accomplish for the pupils more than a fraction of the good that would otherwise come from it. Generally there is a disappointment to both teacher and pupils on leaving it that is relieved only by the joy of a vacation.

In the development of the race, agriculture played a very important part psychically as well as physically, and the child now should not be so wholly deprived of its benefits as he seems to be under modern conditions. Some work, therefore, should be done, and with a natural motive, by each pupil; and fortunate is the one who can complete the season's work in a home garden and gather the ripened psychic harvest with the other.

A few early flowering plants and some early garden vegetables, such as radishes, lettuce, young onions, etc., may mature sufficiently before vacation for the products to be gathered and used; and if the janitor, or some other person, can be secured to care for the garden during the summer, crops of late vegetables and fruits may be enjoyed by the children after school begins in the fall.

In the hope that some of the principles of agriculture may be discovered and applied, the following simple problems are suggested for the pupils to work out in the school garden. Many recitation periods should be spent in the garden.

When spring changes begin, the Natural History Calendar should be resumed in order to stimulate observation and to secure data and specimens that may be needed.

Weeds

1. How do weeds get into the garden? Recall the work done on the scattering of seeds. (See Book I, pp 141-145.)

2. To what extent are weed seeds found in the soil in early spring? Test samples of soil and find out if they contain weed seeds. How may this be done?

3. How can weeds in the garden be prevented next year? What work must be done, and what precautions taken to keep the weeds out of the garden?

4. In hoeing weeds, why must they be cut off as low as possible in the ground? Why will not mowing or cutting off the top kill them?

5. In what ways are weeds harmful in the garden? Allow some to grow among the useful plants and see.

6. Are weeds of any use in nature?

7. Write a list of all the common weeds you know, and tell how their seeds are scattered.

8. How may each kind best be destroyed or prevented?

LESSON XLIX

THE SCHOOL GARDEN—(Continued)

I.—PLANTING

1. Plant the same kind of seeds at various times, care well for them all and see which produce the best crops. Keep a careful record of the dates, conditions, and results during all experiments.

2. Plant similar seeds at different depths and note results.

3. Plant seeds at various distances and determine the amount of room that different plants require.

4. Of what value to the farmer is it to know the best time in which to plant his different crops? What may happen if he plants too early? too late? Give examples of injury to crops through not having been planted at the proper time.

5. If seeds are planted too deep, what may be the result? If not planted deep enough, what harm may it cause?

6. Why should a farmer know just how much seed to plant to an acre? If seed is planted too thick, what harm is done? What is lost if not enough seed is planted?

7. Why do fields of sugar beets always have to be "thinned" early in the spring, leaving the young beets a uniform distance apart?

8. Plant two kinds of seeds together, as corn and squash,

and find out if this is true economy. Does either interfere with the other and make a poor crop?

II.—Irrigation

1. What crops require much moisture?
2. What crops grow well with little water?
3. Supply different rows of plants in the garden with different amounts of water, and find out which are benefited by getting more water than falls as rain.
4. Does it always rain when crops need moisture?
5. If plants suffer long for moisture, will they ever revive and become as vigorous and strong as though they had received all the time the water that they needed?
6. Tell what you know of the effects of a drought.

III.—Rotation of Crops

1. Does the same crop thrive as well when grown year after year on the same land?
2. Can you think of any reason why it should not?
3. If you can, ask some skilled farmer what would be the result of planting the same crop for several years in succession on a given field.
4. Do the same wild plants grow and thrive year after year in the same place? Which do? Which do not? Give a reason for what you have observed about wild plants in this regard.
5. Do farmers near your school change their crops each year?
6. What do the farmers do to make the soil rich and fertile? Why is this needful?

IV—Effects of Various Conditions

1. How do plants behave when it is very hot? Do any die because of the heat in summer?

2. How does very cold weather serve them? Describe the effects of a frost upon the plants in the garden. How does a cold, damp, backward season affect the garden? Do seeds ever rot in the ground because of cold weather? Examine seeds planted early and see if any decay without sprouting.

3. Find out by experimenting in the garden what harm too much shade does to plants. Compare similar plants grown in sunshine and in shadow.

4. In one place in the garden, prepare carefully the soil for planting; and in another place, plant the same seeds without loosening the soil. Discover the difference in results.

5. Keep some plants carefully hoed or cultivated and compare with others of the same kind that are neglected.

6. Uncommon seeds, or those grown in other lands, may be planted and studied.

V—Trees

1. If the garden is large enough to contain trees, tell which are pruned so as to have good shape.

2. Describe how small trees are transplanted. What care should be taken of the roots in digging up a tree? In setting it out? Why?

3. Describe how fruits are gathered, packed, and shipped.

4. Name the different fruits seen at the market and tell where each kind comes from.

5. What kinds have you seen growing?

6. What insects do harm to trees? What are their natural enemies?

7. Why are fruit trees sometimes sprayed? Describe how this is done. Tell why it is done.

LESSON L

GOD'S MIRACLE OF MAY

There came a message to the vine,
  A whisper to the tree;
The bluebird saw the secret sign
  And merrily sang he!
And like a silver string the brook
  Trembled with music sweet—
Enchanting notes in every nook
  For echo to repeat.

A magic touch transformed the fields,
  Greener each hour they grew,
Until they shone like burnished shields
  All jeweled o'er with dew.
Scattered upon the forest floor,
  A million bits of bloom
Breathed fragrance forth thro' morning's door
  Into the day's bright room.

Then inch by inch the vine confessed
  The secret it had heard,
And in the leaves the azure breast
  Sang the delightful word;
Glad flowers upsprang among the grass
  And flung their banners gay,
And suddenly it came to pass—
  God's Miracle of May!

—FRANK DEMPSTER SHERMAN.*

*By courtesy of the author's publishers, Messrs. Houghton Mifflin Company.

STUDY OF BUDS

1. Recall work done on buds in Lesson 18.

2. Collect twigs of many kinds and place them in a bottle of water in a sunny window of the schoolroom; watch the development of the buds.

3. Name and describe the different varieties of buds.

4. Learn to recognize each variety at sight.

5. Note the winter protection of each kind.

6. Which buds contain leaves? Which contain flowers? How can you tell a leaf bud from a flower bud? How may this knowledge prove to be of great value.

7. Are the leaves of all buds folded within the buds in the same way?

8. Which generally burst first, the leaf buds or the fruit buds? Have you ever seen an orchard in bloom? Are many leaves to be seen at that time?

9. Why should fruit buds open first?

10. Do all the buds formed in the fall grow in the spring? (See Experiment, Lesson 18.)

11. What advantage do the buds that grow have over those that do not grow, or that lie *dormant*? Consider position, sunshine, size of buds, etc.

12. Can the dormant buds be made to grow?

Experiment.—From a thrifty twig having dormant buds, cut off all the active buds when they are nearly grown. Watch the effect upon the dormant buds.

13. Of what use to the tree are the dormant buds? When may they be made to grow?

Note.—One spring the tender young leaves of a large mulberry tree near the door of a certain schoolhouse were all killed by a severe frost. The teacher and pupils feared that this would kill the tree. In a few

days, however, all were delighted to see a new covering of leaves on the tree as heavy as the first had been.

14. Where did the second growth come from?

15. Many years ago most of the orchards in the arid west were stripped of all their foliage by the common grasshopper, or locust, leaving the branches and young fruit entirely bare. What do you think happened to the orchard a few weeks later?

16. Dormant buds are like a reserve army, called into action only when needed to meet a danger. Explain the wisdom of this provision.

LESSON LI

RELATION OF BIRDS TO TREES

1. What birds have you seen in trees? Make a list of them. Consult your Natural History Calendar.

2. What birds rarely or never perch upon limbs of trees?

3. Are the feet of all birds adapted for perching upon trees? Describe the feet of different birds that you have seen.

4. Compare the feet of the robin, the woodpecker, and the duck, and tell how each one's feet are made to fit best its needs.

5. What foods do these birds eat? Are these foods found in trees?

6. Compare the beaks of these different birds and tell how each is adapted to the needs of its owner.

7. Tell what you can about the feet and beaks and foods of any of the birds found near the school.

DOING A DOUBLE SERVICE

8. Where do birds build their nests? What birds build them in trees? Describe any nests that you have seen built.

9. Have you ever seen old birds feed their young? What do they bring to the nest to feed the young?

10. How does this habit of the birds benefit man? Does it ever injure man?

A young bird will sometimes eat its own weight of food in a day.

Experiment.—If the nest of a robin or of any of our songsters can be found near the school, watch it all day after the young are hatched and count how many times the old birds bring food to the nest. (Each member of the class may take a turn at the work, beginning at daylight and ending at dark.) Keep a careful record of the time of each visit, what the old one brought, if you can tell, and any happenings of interest. The old birds must not know that they are watched and you may need to hide at a distance and use opera glasses to see what takes place.

11. Mention bugs and worms that injure trees and their fruit. Make a list of them. Bring examples to the school.

12. Tell what damage you have seen done by each. Bring samples of bark, leaves, fruit, etc., injured by insects.

13. Name any insect-eating birds that you know, and tell how and where they catch their food.

Note.—The apple crop in the west has been a partial failure for many years because of the codling moth; and each year millions of dollars worth of crops are destroyed by insects in the United States which the birds would prevent, if there were enough of them. Besides insects, a great quantity of weed seeds also are destroyed by the birds. A single song sparrow has been known to eat enough dandelion seed in a day to seed a good sized lawn and ruin it.

14. What are the chief enemies of these birds?

15. How may we aid to increase their numbers?

LESSON LII

AN ORCHARD

1. What fruit trees have you seen growing?

2. Make a list of all the fruits that grow near your home.

3. If possible, visit an orchard and talk with the owner about the care of the trees and the crops.

4. What trees, and how many of each kind, would you select to plant an orchard of 100 trees to meet best the needs of a family? What trees ripen their fruits early? late? What fruits keep during the winter?

5. Tell how much fruit each kind of tree named will bear in a year when the trees are full grown.

6. Why are trees in an orchard planted in rows? How far apart should rows of various trees be planted? How far apart should various trees be planted in the row? Why?

7. Tell how trees are transplanted. On Arbor Day, or at some other suitable time, transplant some trees and see if they will grow.

8. Visit a nursery and see how the young trees are planted, budded, cared for, and removed and sold.

9. Describe transplanting trees and the setting out of an orchard. What is the proper depth to set out a young tree? How should the roots be arranged before covering them? What should be the condition of the soil into which the young

A Cherry Orchard in bloom

tree is placed? Why are many of the branches trimmed off?

10. Should a fruit tree be tall, or low and spreading? Why? Should it have a long or a short trunk? Should it be one-sided?

11. How may trees be made to grow into desired shapes?

12. Does the best fruit grow in the shade or in the sunshine? On which limbs do we find the best fruit, on those at the top of the tree or on the low shaded ones?

13. Should fruit trees have a dense foliage? How can this be regulated?

14. Is it good economy to cut off large limbs when pruning an orchard? Why? How may the need to do so be avoided?

15. How are different fruits gathered?

16. Tell how each of these fruits is packed and shipped: apples, peaches, apricots, cherries, oranges, bananas, strawberries, raspberries, etc. Give reasons for each method.

17. What care should the ground among the trees receive? What neglect in this regard is common? What are the effects?

18. What useful crops may be grown among the trees when young? Are these secondary crops profitable in old orchards?

LESSON LIII

ORCHARD PESTS

1. Describe changes that have taken place in eggs, larvæ, cocoons, etc., collected or seen since early spring.

2. How were these specimens protected during the winter?

3. What causes them to hatch or change at this time?

4. Most insects pass through how many changes in developing?

5. In which state do they eat most? least?

6. Mention all the ways in which you have seen insects injure an orchard. Which eat the leaf? Which bore under the bark? Which hurt the root? Which suck the sap, or moisture, from the leaves and cause them to wither and drop off?

7. What are the natural enemies of these pests?

8. What means do men use to get rid of them?

9. Tell how orchards are sprayed to get rid of the pests.

10. What insects are killed by using a poison in the spray?

11. What poison is commonly used? Why will not this kill all insects? Would one that sucks the sap, as a mosquito sucks blood, swallow poison sprayed on the surface of the leaf?

12. Tell what you know of the great benefit of spraying to various crops.

LESSON LIV

EFFECTS OF CULTIVATION

1. If a flower bed or garden is neglected, what changes begin to take place at once? What is the effect if the neglect continues long.

2. Compare a well-kept garden with a neglected one.

Experiment.—Neglect one portion of the school garden and notice the results.

3. How will the seeds or fruits of a well-kept garden compare with those of one that is neglected?

4. If the poor seeds of a neglected garden be planted, will they produce as good crops as good seeds will?

5. If a farmer fails year after year to cultivate his crops properly and plants the poor seeds he raises, what will be the effects on his crops in a few years?

6. How can a farmer improve continually his crops? Is it wise to choose the biggest and best seeds to plant? Why?

7. What care should be given the lawn? Do you know of lawns that are not properly cared for?

8. Tell what you can of the care needed by a flower bed; a vegetable garden; an orchard.

Note.—Through proper cultivation our choicest apples have come from the wild, sour, crab apple; our finest double rose, from the common wild rose. The form, size, and quality of most modern agricultural products have been much improved in the same way.

The man who has made the greatest success in raising wheat without irrigation, in the arid west, secures his seed for planting in this way. He keeps in the best possible condition a few acres of his best land on which to raise his seed wheat. When this wheat is ripe and ready to cut, he goes through it and selects the largest, fullest, heads and gathers them by hand into a sack. When he has secured in this way enough wheat to sow for next year's seed, he cuts and threshes the rest of this patch and gets seed enough from it for many hundred acres, whose crop he markets. Next season he sows the hand-selected wheat again for seed, and again selects the best. In this way he has greatly increased the quality and yield of his grain.

LESSON LV

MAKING OUR HOMES BEAUTIFUL

1. What homes near the school look beautiful and inviting? Which do not?

2. Describe the home that you think shows most taste and beauty in its surroundings.

3. What schools and public buildings have beautiful grounds?

4. Is your own home as neat and clean and pretty as you would like it?

5. Can we make our school grounds or buildings look better? How?

6. Is there any rubbish to remove? Are there any paths to level? trees to trim? shrubs to train? lawns to cut?

7. Is there a plot of ground on which flowers could be

BOYS OF THE UTAH STATE NORMAL TRAINING SCHOOL, BUILDING A SCHOOL ARBOR AND PLANTING VINES

planted? Is there a good place to plant a rose bush or a climbing vine or shrub?

8. Draw a plan for walks and garden around a home.

9. Name and describe several ornamental shrubs you have seen.

10. Which bloom? Which do not? Which are annuals

and which are perennials? Suggest suitable places to plant them.

11. Mention flowers that bloom early; others that bloom later; and others that bloom until winter frosts kill them. How may this knowledge aid us in making our homes prettier?

12. Mention beautiful house plants that you know. Which grow from seeds? Which grow from slips? What house plants have you at home? What care do they need?

13. What have you done to make your home more beautiful? What more can you do?

THE BUILDERS

I dwell near a murmur of leaves,
  And my labor is sweeter than rest;
For over my head in the shade of the eaves
  A throstle is building his nest.

And he teaches me gospels of joy,
  As he gurgles and shouts in his toil;
It is brimming with rapture, his wild employ;
  Bearing a straw for spoil.

So I know 'twas a joyous God
  Who stretched out the splendor of things,
And gave to my bird the cool green sod,
  A sky and a venture of wings.

—EDWIN MARKHAM.

LESSON LVI

THE COMMON TOAD

1. Describe a toad.
2. Of what use to it is its color? the roughness of its skin?

3. Describe its movements on land; in water.

4. When is it the more active, during the day or at night?

5. What food does it eat?

6. How does it catch its prey?

7. Where did it pass the winter? Have you ever seen toads plowed up in the spring? How did they become covered so deep in the ground?

8. If possible, bring one to school. It is perfectly harmless. Put it in a box having two or three inches of moist dirt in the bottom. Feed it on insects of any kind—flies, worms, caterpillars, ants, bees, beetles, spiders, etc.

9. How many bugs will a toad eat in a day? Is the toad a friend to man?

10. How many toads can you find near your home?

11. Tell what you know of the good that toads do. Did you ever know of one doing harm?

12. Bring some toad's eggs to school. Where may they be found?

13. Describe the eggs of the toad. How can you tell them from frog's eggs?

14. Keep the eggs in a large glass dish, or in an aquarium, with some water cress, slime, and other plants, and watch them hatch and grow.

15. Describe the changes through which the young tadpoles pass.

16. How many of them live until they get four legs and can hop away for themselves?

17. What enemies have tadpoles? What means of escape or defense have they?

18. A toad will often lay 10,000 eggs in a single season. What would be the result if toads had no enemies?

19. In confinement, see if tadpoles ever eat one another.

20. Have we enough toads to eat the injurious insects?

21. How may their numbers be increased?

22. How long will a toad live?

One toad was kept as a pet for twenty-five years, and another lived in a garden in England for thirty-six years. They can go without food for more than a year at a time with little injury.

23. How does man needlessly destroy many toads?

24. How does a toad drink?

Experiment.—Keep a toad in a dry place for 24 hours, allowing it no water, and then carefully weigh it. Let it sit for a time in mud or shallow water; then weigh it again. What causes his increase in weight?

Note.—Like the frog, the toad absorbs water through the skin.

LESSON LVII

THE EARTH WORM

1. In what places are there many earthworms? Where are there few?

Experiment 1.—Select and measure off a square yard of land where there are known to be earthworms. Count the number of entrances that are found. Sweep the surface clean, and collect and weigh each night and morning all the small heaps of dirt found near the mouths of the entrances.

2. Where does this dirt come from? Is as much dirt placed there in the daytime as in the night?

To find the earthworms at work, look for them early in the morning or in the evening or by the light of a lantern at night. A shower will induce them to come to the surface.

3. What is the average amount of castings every twenty-four hours on a square yard? How much would this be on an acre? How much earth would be brought to the surface of a square yard in three months?

4. Examine this dirt with a lens; compare it with other dirt near. Have the worms improved its quality? Is the earthworm useful or harmful to the farmer?

5. As these earthworms work year after year, what changes will they produce in the soil?

Experiment 2.—With a garden trowel, scrape away carefully the dirt from a worm's burrow until the bottom is reached. Note the size, direction, and depth of the burrow, and whatever may be found in it.

6. Draw a section of an earthworm's home. How deep is it?

7. Is there more than one worm found in a burrow?

8. What does the earthworm eat? Did you find any food in the burrow? What kind of soil do they prefer?

9. How do they bore their way through the ground? Put one or more in a glass of damp earth and study them for a few days.

Experiment 3.—Expose a worm on a piece of paper to the sunshine. Is there any evidence of distress? Dip it into water to moisten its body and see if it then seems to be uncomfortable. Does it prefer light or darkness?

10. How does it crawl? Which end goes first? Touch each end and find out whether one seems to be more sensitive than the other.

11. Try to find out if the worm can see or smell.

12. Examine a worm carefully with a microscope and tell all you can about its structure.

13. Why is it difficult for a robin to draw an earthworm from its hole in the ground?

14. Make a drawing of an earthworm.

15. Describe the eggs of an earthworm.

16. Why are they sometimes called "angle worms"?

17. What great good do these little animals do?

18. Can you find that they injure any useful plants?

LESSON LVIII

STUDY OF INSECTS

1. What insects do you know when you see them? Make a list of all the different kinds that you can think of.

2. Where is each kind found?

Consult your Natural History Calendar.

3. Which are seen by daylight? Which are active at night?

4. Mention insects that fly in the air; that live in the water; that hide in the ground or are found under stones, etc.

5. Which are useful to man? What good do they do?

6. Which are harmful? In what ways?

7. What food have you seen insects eating? What do grasshoppers eat? What foods are eaten by bees? flies? ants? mosquitoes? butterflies? codling moths?

8. Bring to the class samples of leaves, bark, fruit, etc. that you have found partly eaten by insects.

9. Study and describe the mouth parts of the grasshopper, fly, mosquito, or of other common insects.

10. What insects have a sting? For what do they use it?

11. In what ways do insects defend themselves or escape from their enemies? Can you mention any that are pro-

tected by their color? their shape? their speed? their armor?

12. Have all insects wings? Which have two? Which have four? Do all insects need wings?

13. What insects live in swarms or large communities?

14. Which go generally in pairs or alone?

15. Which do great damage when found in great numbers? Which are troublesome in our homes? in orchards? in fields? How do we get rid of them?

16. What natural enemies have insects?

LESSON LIX

LIFE HISTORY OF INSECTS

1. How many legs have most insects? Examine many specimens.

2. What is the greatest difference between the bodies of insects and those of other animals? It is from this feature that they derive their name. The word, insect, means *cut in.*

3. Into how many parts is an insect's body divided? Describe each part. To which part are the wings attached? the legs? the feelers, or antennæ? Examine many insects to see if all their bodies are made on the same general plan.

4. Do insects grow or increase in size? Do we see tiny house flies, others partly grown, and still others fully grown? Observe bees, butterflies, grasshoppers, mosquitoes, and other common insects in this respect.

5. From what do insects come? What changes does an insect undergo in reaching its perfect form from the egg?

Experiment.—Hunt for the eggs, pupæ, or larvæ of any common insects, and collect samples to study. Keep them in conditions similar to those they have been in and watch them develop.

Ants may be observed by putting part of an ant bed into a large glass jar, or into a box with a pane of glass for one side of it. The box should be darkened except when being observed, as ants work better in the dark.

Mosquitoes may be hatched in the schoolroom by getting a pan of water containing "wrigglers," and placing a piece of netting over it to keep the mosquitoes from flying away when hatched.

6. Report to the class all discoveries made about insects, and record in the Natural History Calendar your observations.

7. Draw the different parts of a grasshopper and a butterfly.

LESSON LX

THE HONEYBEE

1. If possible, visit an apiary and talk with the bee-keeper about the bees.

2. Describe a beehive and tell how it is made to serve the needs of the bees. Draw one. Make a miniature hive.

3. Examine the honeycomb. Notice the shape and size of the cells; the thinness of the walls; and how the wise little bee wastes neither room nor wax in building them.

4. Why does not the honey run out while the cells are being filled? Notice how each cell is sealed over when it is full.

5. Where does the bee get its honey? How does it get it? Watch bees while at work among the flowers. Climb into a fruit tree when it is full of blossoms and sit perfectly still for a short time, and you will be surprised at the number of bees you can hear and see at work gathering their store of sweetness.

6. Does the bee get anything from the flowers besides honey?

The yellow balls often seen attached to their thighs are made from the pollen of the flowers and are used in making "bee bread."

7. Examine with a lens the legs of a honeybee. Can you find the little hairs that form the "brushes" and the "baskets"?

8. What good does the bee do the flower in its visits?

9. Are all the bees in the hive alike? Do they all perform the same duties? Tell what you know about the queen; the drone; the worker.

10. Where are the bee eggs laid? By whom are they laid?

11. Describe the growth of the bee from the egg, and tell how the young bee is nursed.

12. Did you ever see bees "swarm?" Describe and explain the swarming of bees.

13. Why are the beehives generally placed on a bench some distance above the ground? What are the most dangerous enemies of the bees?

14. How do the bees defend themselves from their enemies?

15. How does the bee-keeper protect himself when working in a hive?

16. How many pounds of honey may be taken from a hive in a season?

17. Why does the bee-keeper remove the honey from the comb and replace the latter? Describe a honey separator.

18. How do the bees spend the winter?

19. What do you know of their social habits?

LESSON LXI

THE HEN

SILVER-PENCILED WYANDOTTE

1. What kinds of food have you seen a hen eat?

2. What kinds are given her? What kinds does she get herself?

3. How does she get her food? What other birds are "scratchers"? Compare the hen with the quail, grouse, prairie chicken, sage-hen, pine hen, etc.

4. Describe the hen's bill and feet, and tell how they are used in food-getting.

5. How does the hen drink? Why does she raise her head?

6. Why do chickens swallow bits of gravel? How are grains and other hard seeds made fine enough for digestion?

Experiment 1.—When a chicken is "drawn" at home, examine the crop and gizzard and their contents, and infer the use and action of each of these organs.

7. Describe the arrangement, structure, size, shape, uses, and molting of the hen's feathers.

8. What shelter should chickens have? Draw a model hen house.

9. Describe the hen's movements in walking, scratching, flying, etc.

10. Describe the language of hens. Imitate their sounds in crowing, cackling, calling their young, quieting a brood, alarm, etc.

11. Can a hen hear? Where are her ears? Describe them.

12. Can she smell? Do you think she can taste?

Experiment 2.—If possible get a hen that wants to set and put her in a large box or other suitable shelter near the school. Make her a good nest and fill it with as many eggs as she can cover easily. Give her proper food and care and observe her actions until her brood is hatched and reared.

13. How long are the eggs in hatching? Are they ever allowed to get cold? Why? Does the hen ever turn them over? Infer a reason.

BARRED PLYMOUTH ROCK

14. Describe the little chicks, and how they grow.

15. How are eggs hatched artificially? Describe an incubator.

16. Chickens are raised chiefly for what two purposes?

17. Name breeds that are good layers; that are good "broilers" and "friers."

18. How many eggs will a good layer produce in a year? a poor layer? What should be done with the poor layers?

19. What pests often trouble poultry? Suggest remedies. What diseases are common among them? How may they be prevented?

20. Examine an egg carefully: find a purpose in its shape, shell, lining, and contents.

21. What time of year are most eggs produced?

22. When plentiful, how may they be preserved until the time of scarcity?

Note. Besides being placed in cold storage, they may be packed in coarse salt or dipped in a solution of lime and salt to fill the pores in the shell, and kept in a cool place.

FIFTH GRADE—FALL WORK

TO AUTUMN

Season of mists and mellow fruitfulness,
  Close bosom-friend of the maturing sun;
Conspiring with him how to load and bless
  With fruit the vines that round the thatch-eaves run;
To bend with apples the mossed cottage trees,
  And fill all fruit with ripeness to the core
To swell the gourd and plump the hazel shells
  With a sweet kernel; to set budding more,
And still more, later flowers for the bees,
Until they think warm days will never cease,
For summer has o'er-brimmed their clammy cells.

—JOHN KEATS

LESSON I

IMPORTANCE OF WEATHER

TO THE TEACHER.—The weather exerts so constant and important an influence upon all nature that it should receive frequent attention in every grade and throughout the year, until its laws and effects are gradually unfolded to the pupil's mind. In doing this work it is difficult to avoid, entirely, repeating or reviewing work previously done, but each lesson should lead up to the development of a thought that will be new to most of the class.

1. From what you have learned about the weather, describe what it will probably be this fall.

2. What is the average temperature now? What will it be a month from now? two months from now?

3. What will be the chief cause of this change in temperature?

4. Hang a thermometer where it will show the true temperature of the air out of doors. The direct rays of the sun should not fall upon it, nor should it hang in the coldest place on the north side of the house.

5. At regular times during each day observe the temperature. Find the highest, the lowest, and the average of each day and record your observations in a notebook.

6. Find the weekly average temperature.

7. Find the average rate of change in the temperature as the season advances.

8. What kind of storms do we have during the autumn months? Are they frequent? What effect do they have upon crops?

9. When does the first snow storm generally come? Are the crops all gathered?

10. In what part of the United States does snow come first? Why? In what part does it never fall? Why?

11. What parts of the earth are always cold? What zone is always warm?

12. In what zones are changes in weather conditions greatest? Why?

13. Does the weather remain the same throughout the year in any part of the earth? Why do we need changes of weather?

14. If weather changes are unusually severe, or if they fail to occur near their usual time, what may be the effect upon crops? upon herds?

15. Do you know of any failure of crops that was caused by unusual weather conditions?

16. How does a failure of crops affect the price of products? Why?

17. How does a knowledge of the weather aid in securing a better harvest?

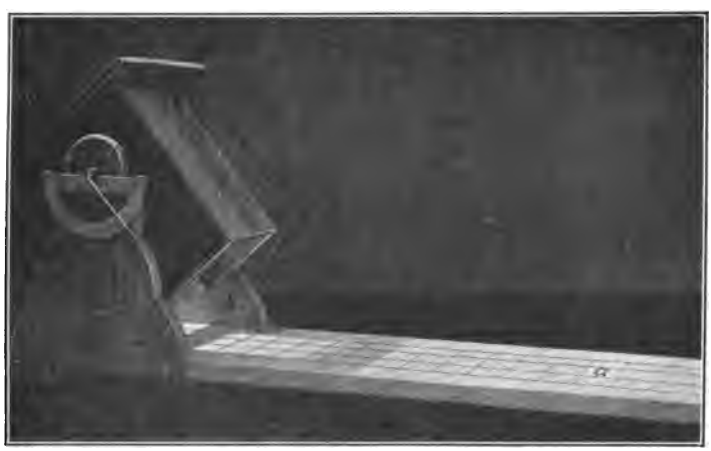
18. Describe the changes gradually taking place in plant life and animal life as winter approaches.

19. What preparations does man make for winter?

LESSON II

DISTRIBUTION OF HEAT

1. What change do you notice in the place where the sun rises?



USING THE SCIAMETER

This sciameter was made by a pupil in the manual training room as follows: A smooth board *a* about 6x20 inches has its upper surface marked off into inch squares. Near one end two uprights *b*, *b* are fastened, and between them the hollow box *c*, three inches square, swings on an axis, to one end of which is fixed a finger that moves with it over a protractor *e*. A spirit-level may be attached at any convenient place to tell when the board *a* is horizontal.

In using the sciameter, place the board in a horizontal position on a north and south line at noon, with the box toward the sun so that its sides are parallel to the rays that pass through it. A sunbeam three inches square then falls on the board and is spread over a certain number of square inches, according to the angle of the sun's rays as shown by the finger over the protractor.

2. Does the sun set in the same place each evening?

3. With the aid of a shadow stick, or a sciameter, find out if the position of the sun at noon is changing. Record your observations.

4. From changes noticed in the position of the sun at these three points, tell what change is gradually taking place in the sun's daily path.

5. Is its path through the sky getting longer or shorter? Why? How does the length of the day affect the amount of heat received from the sun?

6. How does the change in the sun's path change the angle of its rays? How does this change the amount of heat received on any given amount of surface? Illustrate this by a drawing.

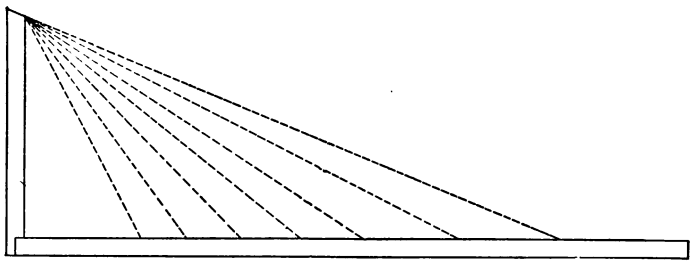
7. Trace with the finger the path of the sun through the sky now; in June; in December. Show the changes now taking place in its path.

8. Compare the changes in average temperature with the changes in the length of day and the slant of the sun's rays.

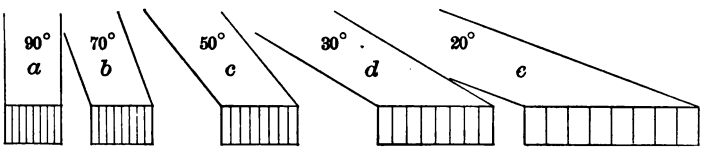
9. By using the sciameter each noon, the movement of the sun can be discovered. By recording the number of square inches daily covered by the sunbeam in it, explain the influence that the change in the position of the sun has upon temperature.

10. Think of experiments and illustrations in nature that show the difference between direct and slanting rays of heat.

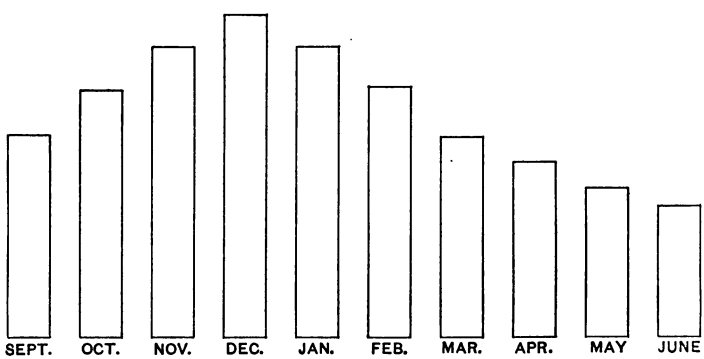
11. When the sunbeam 3 inches square in the sciameter covers 12 square inches, how will the heat falling on 1 square inch compare with that received when the same beam covers 20 square inches?



CHANGE IN ANGLE OF SUN'S RAYS



DISTRIBUTION OF THE LIGHT AND HEAT OF SUN'S RAYS AS AFFECTED BY THE ANGLE AT WHICH THEY STRIKE A SURFACE



SHADOW CHANGES DUE TO THE CHANGE IN SLANT OF THE SUN'S RAYS EACH MONTH

12. What, then, is the chief cause of the changes of the average temperature?

13. What effect has the shortening of the day upon the

amount of heat received from the sun? Prove this by experiments or by illustrations from nature.

14. Illustrate by means of the shadow stick and drawings the same principles as are shown by the sciameter.

LESSON III

EFFECTS OF SUNSHINE

1. What month in the year has the most sunshine?

2. In which month is there most cloudiness? Is there any relation between cloudiness and rainfall?

3. Keep a sunshine chart during the year.

(See Fourth Grade, Lesson 11, p. 18.)

Experiment 1.—Cover two similar potted plants with glass jars. Place one in the direct sunshine and the other in the dark for a short time. Note which plant gives off the more moisture as shown by the water condensed on the inner walls of the glass jars.

4. Infer from this experiment which plant is the more active.

5. Compare the growth made by plants in a dark cellar with that of plants growing in the sunshine.

6. On which branches of a tree are the largest and strongest leaves? the biggest and best fruits? Why?

7. Why can more sugar be made from a ton of beets raised on irrigated lands in Colorado or Utah, than from a ton raised in the regions of the Mississippi valley where there is so much more rainfall? What states make the most beet sugar?

8. In Salt Lake City, 269 days in the year are days of sunshine, and in Denver, 304. How do these compare with the amount of sunshine in New Orleans? in Chicago? in New York? in your own locality?

9. Alfalfa is a plant that yields three crops of hay during the summer. How will a long, cloudy spell affect the crop?

10. Learn by studying the daily weather maps and reports what parts of our country have most cloudiness and what parts have most sunshine.

11. Prove that plants love sunshine and seek it.

12. Do any plants thrive best in the shade? Name some.

13. Do plants ever get too much sunshine?

Experiment 2.—Place a fern or some moss in the strong sunshine and see if any bad effects follow.

14. Notice carefully both wild and cultivated plants that grow in the shade, and compare them with plants of the same kind growing in the sun.

15. How may weeds in the garden affect the supply of light needed by the useful plants there?

16 What plants grow under the trees in the woods? How do they contrive to get light enough for their needs? Are they as numerous and as thrifty as plants under similar conditions growing in sunshine?

LESSON IV

LENGTH OF THE DAY

1. For a few weeks notice the time of sunrise and of sunset, and find out just how fast the length of day and night is changing.

2. Which month contains the longest days? What can you say of the length of the nights in this month?

3. Which month contains the shortest days? the longest nights?

4. Does the length of the day correspond in any way with the length of the sun's daily path through the sky?

5. How does the length of the day affect us? When do we need longest days?

6. How do long days affect the temperature? Why? Do they affect plant growth? How?

7. Find the longest day in the year; the longest night.

8. Explain the cause of the change in the length of day and night.

LESSON V

WEATHER.—CAUSES AND EFFECT

1. How do the sun's rays strike the various parts of the earth's surface? If you were at the equator at noon about September 20, where would the sun appear to be? If at New York, where would it appear to be? If at the north pole, where would it seem to be?

Experiment.—Hold a globe in the sunshine and show how the sun's rays fall at various angles on its different parts. Illustrate the same principle by drawings on the blackboard.

2. Describe the apparent movements of the sun during the year.

3. Account for the four seasons in the temperate zone as resulting from the yearly motion of the sun.

In the summer the sun comes northward until its vertical rays fall $23\frac{1}{2}^\circ$ north of the equator. In the winter it goes as far south.

4. Locate the five zones as a result of this movement. Tell what you know of the temperature of each zone and what makes it have that temperature.

5. What must be the seasons in each zone as fixed by this movement of the sun?

6. How does the climate in each zone influence plant life? What plants grow in the frigid zone? in the temperate zone? in the torrid zone?

7. Tell what you know of the effects of a cold, backward spring, or of a late frost upon crops. How may an early fall influence crops?

8. What would be the result if the farmers in one zone should plant the crops grown in either of the other zones?

9. How do the changes in temperature, length of day, etc., influence animal life in the fall in this zone?

10. From the Natural History Calendar tell what animals are disappearing. Why are they going? Where are they going?

11. How do we care for our domestic animals during the winter?

12. How do winter dwellers keep comfortable during the cold weather?

13. In which zone is man the happiest and most civilized? Where is he most indolent and lazy? Infer a reason.

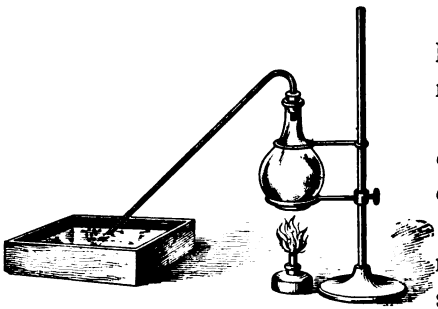
14. Explain how climate influences man's occupations and development as well as it does the growth of animals and plants.

LESSON VI

CAUSES OF WIND

Experiment 1.—Heat the air in a Florence flask and conduct the overflow through a perforated cork and bent glass tube under the surface of water. Account for the escaping air bubbles.

Remove the flame and cool the flask. Account for the water being drawn into the flask.



1. Why does a balloon filled with hot air rise?

2. Account for the draught of a stove or chimney.

3. Why does the air rise above the heated stove or radiator?

4. Give many illustrations proving that hot air rises.

Experiment 2.—In a beaker of water place a few particles of chalk dust, wet sawdust, or other substance that will neither sink nor swim readily, but remain suspended in the water. Hold a flame under one side of the beaker and note by the moving particles the movements of the water caused by the heat.

5. Why does the water rise immediately above the flame?

6. Why does it flow downward on the other side?

7. What is the effect of heat upon air? upon water? (See Fourth Grade, Lesson 29.) Do you remember whether heat ever expands solids?

8. If a given quantity of air or water is thus expanded by heat, how will its weight compare with that which is not so expanded? Can you illustrate this law by other examples?

9. What will be the effect if air becomes very warm over a given area—warmer than the surrounding air?

10. As the heated air rises, what takes its place?

This movement of air is called *wind*.

11. What part of the earth's surface is warmest? Where,

then, will most air be made to rise? In the immediate area where the air is rising, no wind is felt. Why?

12. Why do the great regular winds blow toward the equator from both poles? Do they blow directly south in this hemisphere and north in the southern?

Experiment 3.—Cause a globe to be revolved on its axis, and note the greater distance covered by a point at the equator than by one near the pole, in making a revolution. As the air at any given point has about the same forward movement as the surface of the earth at that point, all air moving toward the equator will naturally lag behind in the motion from west to east.

13. The above law will give these winds what direction if north of the equator? if south of it?

TO THE EVENING WIND

Spirit that breathest through my lattice, thou
  That cool'st the twilight of the sultry day,
Gratefully flows thy freshness round my brow:
  Thou hast been out upon the deep to play,
Riding all day the wild blue waves till now,
  Roughening their crests, and scattering high their spray
And swelling the white sail. I welcome thee
To the scorched land, thou wanderer of the sea!

Nor I alone—a thousand bosoms round
  Inhale thee in the fulness of delight;
And languid forms rise up, and pulses bound
  Livelier, at coming of the wind at night;
And, languishing to hear thy grateful sound,
  Lies the vast inland stretched beyond the sight.
Go forth into the gathering shade; go forth,
God's blessing breathed upon the fainting earth!

Go, rock the little woodbird in his nest,
  Curl the still waters, bright with stars, and rouse

The wide old wood from his majestic rest,
  Summoning from the innumerable boughs
The strange, deep harmonies that haunt his breast;
  Pleasant shall be thy way where meekly bows
The shutting flower, and darkling waters pass,
And where the o'ershadowing branches sweep the grass.

The faint old man shall lean his silver head
  To feel thee; thou shalt kiss the child asleep,
And dry the moistened curls that overspread
  His temples, while his breathing grows more deep;
And they who stand about the sick man's bed,
  Shall joy to listen to thy distant sweep,
And softly part his curtains to allow
Thy visit, grateful to his burning brow.

Go—but the circle of eternal change,
  Which is the life of nature, shall restore,
With sounds and scents from all thy mighty range,
  Thee to thy birthplace of the deep once more;
Sweet odors in the sea-air, sweet and strange,
  Shall tell the homesick mariner of the shore;
And, listening to thy murmur, he shall deem
He hears the rustling leaf and running stream.

—WILLIAM CULLEN BRYANT.

LESSON VII

THE WEATHER BUREAU

1. Have you ever visited a Weather Bureau station? If so, describe what you saw and tell what work is done there.

2. What reports are issued daily?

3. What predictions are made concerning the weather?

4. How long beforehand can the weather be predicted with a degree of certainty?

5. How does the telegraph aid the Weather Bureau in making its predictions?

6. At what rate do the most rapid storms move?

7. Knowing the velocity and direction of a storm, or cold wave, how may its time of reaching any given city be predicted?

8. How will a foreknowledge of the approach of a cold wave or "killing frost" be a benefit to a gardener? a fruit raiser?

9. What precautions do sailors take when warned of a coming hurricane?

10. Tell in what ways the following people may avoid loss or inconvenience by knowing the day previous that it will rain—the school-boy, the wash-woman, the carpenter, the pleasure seeker, etc.

11. How has a warning of the approach of a hurricane saved people's lives?

12. What harm is done by a cold wave or a hot wave that might be lessened through knowing beforehand of its approach?

13. Describe a weather map. What information does it contain?

14. Are the people in one part of the United States benefitted by knowing the kind of weather that the people in some other part are having? Illustrate this.

15. Why do all civilized nations maintain many weather bureau stations?

16. Besides their influence in saving lives and property, how do they add to our knowledge of the laws of weather?

17. Study the signals used to denote different weather conditions.

LESSON VIII

CAUSES OF PRECIPITATION

1. Review the laws of evaporation and condensation given in the Fourth Grade (See Lessons 10, 39, 40, and 41.)

2. On what part of the earth's surface is there the greatest evaporation? Is it a good thing that three fourths of the earth's surface is water? How do you think it would affect the rainfall if three fourths of the earth's surface were land?

3. In what zones does evaporation occur most rapidly? Why?

4. How does the vapor from the ocean reach inland?

5. In traveling inland, what things may cause a change in the temperature of the vapor from the ocean?

6. If the vapor pass over a mountain, what change is produced? What effect will this change in temperature cause? Prove that mountains are colder than low land.

7. When a cold current of air comes against a warm current, what may happen to the vapor in the latter?

8. When the moist air near the ground becomes very warm, as on a sultry day in summer, what movement is it likely to take? Why does hot air rise?

9. As this warm air rises, how will it affect the barometer? Why?

10. When it reaches the cold upper regions, what will happen? The amount and rapidity of rainfall is influenced by what conditions?

11. Does snow or ice ever evaporate without melting?

When air is very dry, it takes up moisture even when very cold.

12. Under what conditions is snow formed? Do you think snow can pass to vapor, and vapor pass to snow, without first turning into water?

13. Describe a hailstorm, and conditions under which it occurs.

TO A CLOUD

Beautiful cloud! with folds so soft and fair,
  Swimming in the pure, quiet air!
Thy fleeces bathe in sunlight, while below
  Thy shadow o'er the vale moves slow;
Where, midst their labor, pause the reaper train,
  As cool it comes along the grain.

* * * * * * *

Bright meteor! for the summer noontide made!
  Thy peerless beauty yet shall fade.
The sun, that fills with light each glistening fold,
  Shall set, and leave thee dark and cold;
The blast shall rend thy skirts, or thou mayest frown
  In the dark heaven when the storms come down;
And weep in rain till man's inquiring eye
  Miss thee, forever, from the sky.

—WILLIAM CULLEN BRYANT.

LESSON IX

REGIONS OF HEAVY AND LIGHT RAINFALL

1. What part of the United States has a heavy rainfall? Account for this. Consider the directions of the winds, the location and size of mountains, etc., as influencing rainfall.

2. How does this influence the crops? the population?

IRRIGATING STRAWBERRIES NEAR PROVO, UTAH

3. What part of the United States is arid and used to be called the Great American Desert? Account for this. Consider distance from the ocean, intervening mountains, direction of winds, nature of surface, etc.

4. What substitute for rainfall do farmers use in the arid regions? How is this affecting the population of these regions?

5. Describe methods of irrigation.

6. How is our government aiding irrigation in the arid regions?

7. What countries have greatest rainfall? Why?

8. How does the abundant heat and moisture in the tropics affect vegetation? Describe a tropical forest.

Note.—Fields of alfalfa in the tropics yield ten crops a year, while market gardens often are made to yield three. Roads through forests will grow up and become impassable in a few days, if not kept clear.

8. Account for the size of the Amazon River. If the Andes Mountains extended entirely around the coast of South America, how would it change the size of that river? What would be the effect upon the interior?

9. Suppose the ocean winds were to change from the east to the west in South America, what changes in the rainfall do you think would follow there? In the southern part of South America the winds do come from the west. What is the effect upon the rainfall there? Which is the more productive, Chili or Argentina? Why?

10. Why is Sahara a desert? What changes in the surface of Africa would you suggest to cause more rain in that region?

11. Compare the annual rainfall of various countries and account for the differences noticed. Consult a good geography.

The mean annual rainfall in New Orleans is 63 inches; in Chicago, 34.55 inches; in Salt Lake City, 16.2 inches.

Note.—Scientists say that enough heat comes from the sun each day to evaporate half an inch of water from the entire surface of the ocean. If all this were brought by the winds to the land and fell as rain, it would give us a daily shower of an inch and a half, or an annual rainfall equal almost to the flood.

LESSON X

RESPIRATION

Experiment 1.—Count the number of times that you breathe in one minute. The whole class may do this while the teacher marks the time. Repeat the experiment several times until all can breathe naturally while counting. Find the average number of respirations per minute for the class.

Experiment 2.—Fill a half gallon fruit jar with water and invert it over a vessel containing water, keeping its mouth under the surface so that the water will not run out. Insert the bent end of a glass tube under the mouth of the jar, and breathe through it until the water is displaced by the exhaled air. Repeat this several times, breathing as naturally as possible, and find the average number of respirations necessary to displace the two quarts of water.

In a similar way, by exhaling all the air possible at one breath, the capacity of the lungs of various pupils may be tested.

Note.—Since conscious breathing is apt to be unnatural, the foregoing experiments should not be regarded as accurate, but as a basis for some interesting calculations upon the amount of air a person needs every hour.

1. If a pupil breathes 18 times every minute and exhales each time 1 pint of air, how many gallons will he exhale in a minute? in an hour?

2. If one pupil exhales $2\frac{1}{2}$ gallons of air in a minute, how many gallons will all the pupils in the room exhale in a minute? in an hour?

Since one gallon contains 231 cubic inches, express the answers to the last queries in cubic inches and cubic feet.

Experiment 3.—By means of a straw or glass tube, pass the breath through a glass of limewater and note the milky color given to the limewater. This is due to the formation of a kind of chalk dust in the water and proves that a gas called carbon dioxide is in the breath.

3. What do you remember about this gas? (See Fourth Grade, Lesson 31). Compare it with oxygen.

Experiment 4.—Breathe into a wide-mouthed glass jar several times until the breath has displaced all the air. Close it tightly and keep it in a warm place for a day or two. The foul odor developed tells of the presence of organic matter in a state of poisonous decay.

4. What will be the effect upon the surrounding air of pouring into it $2\frac{1}{2}$ gallons a minute of exhaled air laden with its carbon dioxide and other impurities?

5. The amount of foul matter exhaled by a grown person in an hour is enough to make 3,000 cubic feet of air unfit to breathe. If a pupil exhales $\frac{2}{3}$ as much as an adult, how much fresh air should enter the room each hour to insure a sufficient supply for all the pupils in it?

6. Measure the ventilating flues and estimate the speed of a stream of air necessary to give the amount needed.

7. What are some of the dangers of foul air?

8. Should children in bed cover their heads? Why?

9. Should a child be shut in a small closet long as a punishment? Why?

10. Is cold air always fresh? Should windows in sleeping rooms be raised as well in winter as in summer?

11. What is the danger in allowing a cold draught to strike one?

12. Do we use as much air when asleep as when awake? How does exercise affect our breathing?

13. Do all animals in proportion to their size need as much air as man does?

14. Which animals seem to use little or no air during the winter?

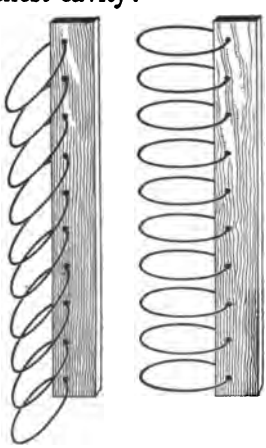
LESSON XI

RESPIRATION (Continued)

Experiment 1.—Inhale a long, deep breath. Exhale as completely as possible. Repeat several times and notice the action of the chest and abdomen each time.

1. Describe the movement of the chest when we inhale; when we exhale. How do these movements influence the size of the chest cavity?

2. How do the walls of the abdomen move when we inhale all we can? How do they change as we exhale all we can? How will these movements increase or decrease the size of the chest cavity?



Experiment 2.—A number of rings attached at equal distances to an upright rod are allowed to hang downward. Notice the size of the cavity they enclose as you look down the rod. Now raise the rings until they stand at right angles to the rod, and notice the greatly increased size of the cavity which they encircle.

3. Compare the ribs attached to the backbone with the apparatus just described and account for the rising and falling of the chest while breathing.

4. How will a stooped-over position influence respiration, or breathing?

5. Describe a healthful position and give reasons.

6. How does clothing often interfere with free breathing?

Describe proper and improper kinds of clothing in their relation to breathing.

7. What habits of exercise will promote good respiration?

8. Why do we need much fresh air to pass into our lungs?

9. Mention habits and occupations that keep us from getting all the fresh air that we need.

10. Are bed curtains healthful?

11. Is there any good in sighing? Why do we gape, or yawn?

LESSON XII

VENTILATION

1. At what season of the year is ventilation most perfect? Why? When is it most imperfect? Why?

2. When do we need to give the most careful attention to ventilating our homes and schoolrooms?

3. Describe ways of ventilating rooms at home. Should currents of cold air enter a room where they will strike the occupants? Why?

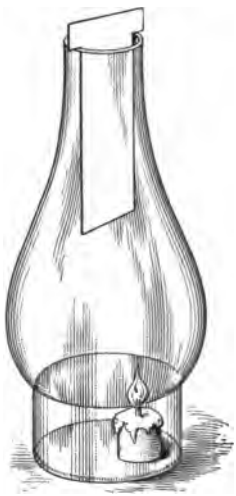
4. What is the chief cause that makes air currents? Recall the effect of heat upon gases and liquids.

(See Fourth Grade, Lesson 29.)

Experiment 1.—Hold a thermometer for a few minutes near the floor and then near the ceiling. Note and account for the difference in temperature.

Experiment 2.—Place a lamp chimney over a short piece of candle, lighted. Note the current of air it creates, especially if a piece of cardboard be lowered as shown in the cut on p. 126, dividing the space for an upward and a downward current to pass.

Experiment 3.—With a flame, or smoke-paper, detect and trace the air currents near a stove, furnace, grate, radiator, or any opening near the ceiling or floor. Account for the movements discovered.



EXPERIMENT 2

5. Where is the air found to be moving upward? Why? Downward? Why? Outward? Why? Inward? Why?

6. Compare the old-fashioned fireplace and the modern heating stove as to their influence upon the ventilation of our homes.

7. If the schoolroom has a modern ventilating plant, study it carefully. Find out and explain how schoolrooms are supplied with fresh, warm air.

8. Why is one so apt to take cold when sitting near the cold wall in a large building?

9. Should all the fresh air needed in a room enter from a single window, or a little from each of several? Why?

10. Should the air be admitted at the top or bottom of the windows? Why?

11. Why do we not re-inhale at once the air we exhale? Watch the breath on a cold morning when it can be seen, and find out if any of it is immediately drawn back into the lungs, and how nature has a way to prevent this evil.

12. What is the effect upon us of breathing impure air? Is cold air always pure?

13. What occupations afford most fresh air?

14. What tradesmen do not have enough pure air?

15. Mention evil effects of breathing impure air.

16. Show how the constant tendency of the air to move is a good thing for the health of the people.

LESSON XIII

CARBON DIOXIDE

Experiment 1.—To obtain some carbon dioxide to examine, pour a few drops of hydrochloric acid upon a piece of limestone or marble in the bottom of a glass jar; or use vinegar on bicarbonate of soda in the same way. Lowering a piece of lighted candle into the jar and allowing it to remain until the light goes out, or breathing into it several times also will produce a supply of this gas, though not so pure as that produced by the first method.

1. What is the color of carbon dioxide? Has it an odor?

2. How may it be detected?

Experiment 2.—Lower a lighted candle into this gas; or pour some of it from the jar over the flame of the candle as if it were water. Describe the result.

3. How does its weight compare with that of air?

4. If a small animal were dropped into a jar of carbon dioxide, what would be the result?

5. How can we tell the presence of this gas before entering it?

Note.—A workman once fell into what looked to be a deep, empty vat in a tannery. It was full of this gas, however, and he died before assistance could rescue him.

6. From the weight of this gas, in what places do you think it will likely be found?

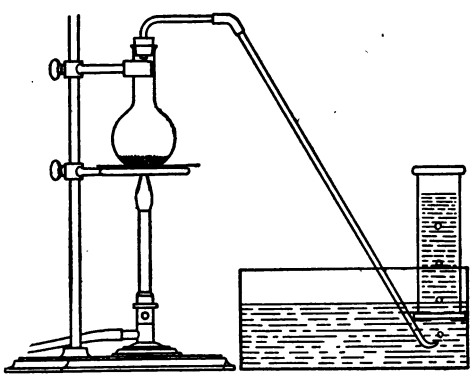
7. Why do workmen lower a lighted candle into an old well or mine shaft before entering it?

Note.—Great quantities of carbon dioxide are produced in nature not only by the breathing of animals, but by combustion, decay, and other processes. Plants have the power to use up this gas and free the air from an excess of it; otherwise, animal life would soon perish from the earth.

8. How is lime water affected by a contact with carbon dioxide? What use is made of this fact?

LESSON XIV

OXYGEN



Experiment 1.—Under the direction of the teacher, oxygen gas may be made in the following manner:

Mix equal parts of black oxide of manganese and potassic chlorate in a large test tube fitted with a cork through which passes one end of a glass tube. The other end of the tube reaches under a bottle of water inverted and having the mouth below the surface of the water in another vessel, as shown in the illustration.

Apply heat to the mixture and oxygen will be given off and pass along the glass tube, until as bubbles it displaces the water in the inverted bottle. Several bottles may be filled with oxygen in this way for use in experiments.

1. Explain the arrangement of the apparatus described.
2. Will the first bubbles of gas be pure oxygen? Why?
3. Why does the oxygen take the place of water?

Experiment 2.—Light a match or small splinter. When it has burned long enough to leave a live coal at the end, blow out the flame and thrust the live spark at once into the oxygen.

4. Account for the results.

5. How does oxygen differ from carbon dioxide in its influence upon combustion?

Experiment 3.—Place a small piece of phosphorus into oxygen gas; if dry, it will usually burst into a flame.

6. Why is phosphorus usually kept submerged in water?

Experiment 4.—Heat red hot a piece of watch spring to take out the temper. Straighten it and file one end thin and pointed. Dip this end into sulphur and then into a flame to light the bit of sulphur on the end. Quickly place this end into a bottle of oxygen and the steel spring will burn with a beautiful light.

7. Why is the sulphur used in this experiment? Compare with its use on a match.

8. What power of oxygen is shown in all these experiments? How does it compare with carbon dioxide?

9. One fifth of the atmosphere is oxygen. How would a greater proportion influence all kinds of fires?

10. If steel burns in oxygen gas, what might happen to the earth itself if the atmosphere were all oxygen?

11. Why is a good supply of air needed in all cases where a good fire or rapid combustion is desired?

12. What would be the effect of breathing pure oxygen gas?

Note.—An animal placed in oxygen gas seems to be stimulated very greatly, and in a short time will die in the greatest apparent excitement, if not removed. Physicians sometimes use it in extreme cases as a powerful stimulant.

LESSON XV

EVERGREEN AND DECIDUOUS TREES

1. Bring to the class sample twigs from various kinds of evergreen trees and of trees that shed their leaves. The latter are called *deciduous* trees.

Note.—Good pictures of both kinds of trees should be at hand, unless the trees themselves can be seen.

2. Compare the leaves of the two kinds and give reasons for the differences noticed. Why is one kind broad, flat, and thin, while the other is long, slim, and needle-shaped? Which kind would catch and hold most snow in a snow storm? Which are sometimes eaten by animals as food?

3. Try to break or tear the leaves. Which kind is the tougher? Which is the more subject to fierce winds that might beat them to pieces?

4. Compare them as to numbers. How does the evergreen make up for the small size of its leaves? Which kind of tree do you think will have the greater leaf surface?

5. Notice the fine, compact structure of the one and the coarse, loose, veinings of the other, and think of a purpose in this.

6. What difference do you notice in the arrangement of the leaves on the twigs? Is there a wise purpose in this?

7. Where are the most vigorous leaves generally found on a deciduous tree? on an evergreen?

8. Does an evergreen ever shed its leaves? When? How long does an evergreen leaf do service?

9. What would be the result to most deciduous trees if they did not shed their leaves in the fall?

10. Try to discover just how they get rid of their leaves when the right time comes.

11. Compare the two kinds of twigs. Test, by bending, the toughness of each. Why are the evergreen branches so

PROPS USED TO PREVENT THE HEAVILY LADEN LIMBS OF A YOUNG PEAR TREE FROM BREAKING

tough? If they were brittle, what harm would come to the tree? What deciduous trees need toughest branches? Why?

12. At what angle do the branches of each leave their respective trunks? Is there an advantage in this?

13. Why should the branches of the evergreen extend outward horizontally, or even slope downward as some do?

Note —The heaviest snow storm ever known in Salt Lake City fell there in the autumn of 1908. Hundreds of shade and fruit trees, for which the city is noted, were ruined by having their largest limbs broken down by the loads of snow that clung to the unshed leaves and branches,

but only a few of the many evergreens found on the lawns and gardens suffered any injury whatever.

14. What loads besides snow sometimes break down trees?

15. What trees have you seen injured in this way? How may they be protected from this danger?

LESSON XVI

EVERGREEN AND DECIDUOUS TREES (Continued)

1. What general difference do you see in the shape of evergreen and deciduous trees?

2. How is the cone shape of the former secured? Consider the size and shape of the trunk, and the size and arrangement of the branches. Compare with deciduous trees.

3. Which trees are most liable to be split open and ruined by heavy loads of any sort on their limbs? Which kind has the most of such loads to carry?

4. In the case of most evergreens, on what part of each branch does the snow fall? Note how the branches are arranged in whorls, like umbrellas, around the trunk, growing smaller from the ground upward. What is the purpose of this arrangement?

5. Compare the bark of the two kinds of trees. Consider color, odor, thickness, toughness, surface, etc., and find adaptations to the various needs of the trees.

6. Why do some trees need thicker and rougher bark than others? Mention things that injure trees.

7. Are evergreens the best shade trees?

8. Would it be well for fruit trees to have a cone shape?

9. Do the high, sunny branches, or the low, shady ones have the fine fruits? Does this suggest a reason for the wider spreading branches of fruit trees, and a hint for pruning a young orchard?

10. Which of these two kinds of trees is the more useful to man? Mention all the uses to man of the evergreen trees, of the deciduous trees. Which uses depend upon habits of growth?

11. Which kind furnishes the more lumber? Why?

12. Which makes better shade trees?

13. Which kind is beautiful and used for ornament?

14. Which is the more abundant?

15. Which grows in dense forests?

16. What parts of our state contain forests?

17. Where are the forest regions of the United States?

LESSON XVII

LUMBERING

1. Secure samples of as many kinds of lumber as possible.

2. Learn to recognize each kind at sight.

3. Which kinds are hard? Make a list of the hard woods

4. Which kinds are soft? Make a list of them.

5. Describe each of the following kinds of wood and mention at least one thing for which each is used; pine, oak, poplar, cedar, rosewood, mahogany.

6. What causes the grain seen in most wood?

Experiment 1.—Take a piece of a limb or trunk of a small tree, about three or four inches in diameter and a foot or two long—if possible, one

that contains a knot—and saw it into miniature boards. Without trimming the edges of the boards, plane and sandpaper their surfaces and study the grain in each.

7. What relation has the grain, seen in the surface of the board, to the rings seen in the end of the log from which they were made?

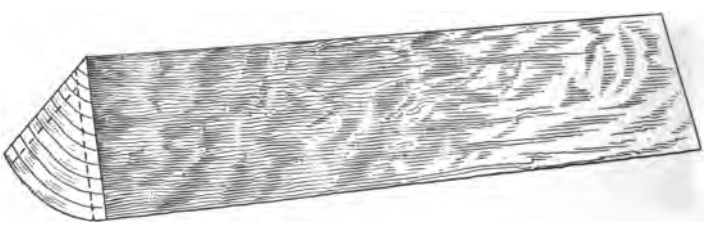
8. How does a knot affect the grain?

9. Can you tell which side of a board is the "heart side?"

10. What kinds of lumber are valuable for their beautiful grain?

11. Which kinds are prized because of the high polish they can receive?

12. Why is quarter sawed oak more valuable than that sawed in the ordinary way?



Experiment 2.—Take a piece of an oak limb of convenient size and saw it lengthwise through the center. Saw one half of it into miniature boards as in Experiment 1. Saw the other half down the center, cutting it into two quarters of the original piece. Cut boards from both faces of one of these quarters and surface them.

13. Which boards have the more beautiful surface?

14. Which method of sawing is the more economical?

15. Why is quarter sawed oak worth more than the other?

LESSON XVIII

LUMBERING (Continued)

1. What trees are best adapted by shape to make lumber?

2. What should be the shape of trees to furnish the best lumber? What should be the size of the branches compared with that of the trunk? Why are the cone-shaped trees best?

3. What habit of growth is necessary to make lumbering profitable? Why?

4. Visit a logging camp and a sawmill, if possible, and study the methods used in converting trees into lumber.

Note.—Good pictures will aid much in giving correct ideas of this industry. A visit to a lumber yard and planing mill can be made by most classes where many operations with lumber may be seen.

5. How are the logs cut down? When is the best time to cut them down?

6. How are they moved to the mill? When is this part of the work done to the best advantage?

7. How does snow aid in moving them?

8. How does high water in some places aid in moving them?

9. In cutting out the large trees for lumber, what care should be taken of the small ones? Why?

10. What time of the year are forest fires most dangerous? What care should be taken to prevent them?

11. Describe a circular saw and tell how it works.

12. Describe a band saw and show its advantages.

Note.—A number of saws fastened to a frame may be made to saw many boards at once. Such an arrangment of saws is called a "gang saw."

13. Describe any method of sawing that you may have seen.

LOGS BEING FLOATED DOWN THE RIVER TO A SAWMILL

14. How is the length of lumber fixed? its width? its thickness?

15. How are logs "fed" into a mill?

16. How is the lumber carried off and trimmed?

17. What waste is there in lumbering? What are slabs and how are they sometimes used?

18. What uses are made of sawdust?

19. What part of a log goes to waste in making lumber?

20. Describe how lumber is shipped by land and by water.

21. Where are the great lumber regions of the United States?

22. What is the price of various kinds of lumber?

23. What wasteful and unwise destruction of the forests has been practised until recent years in the United States?

24. What would be the consequence if all our forests were used up?

25. What efforts are now being made to keep up a supply of lumber in our nation?

FIFTH GRADE—WINTER WORK

LESSON XIX

STUDY OF A FOSSIL

TO THE TEACHER:—No school cabinet is complete without a number of fossils, and this lesson should not be given without samples that the pupils may handle and study. In this case we will suppose the sample to be a fossil fish; but with slight changes the lesson will serve as well for a fern, a piece of wood, the track of an animal in the mud, turned to a stone, or almost any common fossil.

1. Examine carefully the specimen. What made this imprint in the stone?

2. What is there about it that causes you to conclude it was a fish? Consider the size, shape, and features that resemble a fish.

3. Is any of the original substance of the fish preserved?

4. How may the fish have become imbedded in the stone?

5. Was this always a stone? What about it indicates that at one time it was mud and under water?

6. Does mud ever change to stone? Have you ever seen it harden in any way? Consider mortar, clay, cement, brick, etc., and how each is hardened by man.

7. How may similar results be obtained in nature? What do you think about the time it takes nature to do such work?

8. Where do fishes live now? What do they eat? Did similar conditions exist when this fish was alive?

9. What must have been the temperature of the water in which it lived? Can you tell whether it was salt or fresh water?

10. What were the conditions of the weather when this fish lived? of the atmosphere? of sunshine? of plant life? of animal life? What makes you think so? How does this fossil prove these conditions?

11. Under what conditions may this fish have died and become covered with mud? Do fish nowadays ever get buried in mud?

12. Where was this fossil found? How did it happen to become uncovered?

13. How do you think such fossils are formed?

14. Have you ever seen leaves, branches, snails, clams, etc., imbedded in the mud by natural causes?

15. Examine the mud along ditch banks or margins of ponds, lakes, swamps, etc., and discover how animals and plants may become imbedded in mud.

16. What damage is often done by high water? Have you ever seen trees, lumber, parts of buildings, bodies of animals, etc., swept down the current of a river in time of high water?

17. What becomes of such freight when the water finally reaches the quiet sea?

When these objects sink to the bottom and are covered with the mud that settles over them, they may gradually become fossils imbedded in mud, which the great weight of water above gradually turns into stone. Future generations may discover and study them.

Experiment.—Make some artificial fossils by pouring some clayey mud into any convenient vessel and let it partly dry. Then place on top of this a small stick, leaf, or insect and cover with more mud. When the whole is dry, there will be little difficulty in separating the hardened mud so as to show the fossils.

18. Collect fossils of any kind for the school cabinet and study them.

LESSON XX

STUDY OF COAL

1. Bring samples of different kinds of coal to school to study. Let the collection contain, if possible, pieces of anthracite, bituminous, and cannel coal, peat, coke, charcoal, lignite, etc.

Experiment.—Note the color, hardness, weight, etc., of the samples at hand and see which will burn by holding a fragment of each in a flame by means of pinchers.

2. Visit a coal yard and see how coal is handled there.

3. If practicable, visit a coal mine, or find out from a coal miner all you can about how coal is mined.

4. What is the use of coal?

5. What did people do for heat before coal was discovered? Did they use heat then as much as we do now?

6. What substitutes do people use now who live in countries where there is no coal?

7. What kinds of coal do you use at home? What does a ton cost? How long will a ton last?

8. What kind is used in school? How much is used in a month? during the year?

9. From what mines is the city supplied with coal?

10. What things are made possible by the use of coal?

11. Describe some of the results if all the coal mines should become exhausted.

12. Find out all you can of the history and growth of the mines that supply your city with coal.

Note.—In Utah the pioneers burned wood for several years, until it seemed that the scanty supply would all be used. The legislature offered a large reward to any one who would discover a bed of coal 18 inches thick within 40 miles of the capital. A mine was soon opened at a town called Coalville and the needs of the people supplied. Many mines in various parts of the state have been discovered and developed since. The history of coal development in Pennsylvania, West Virginia, Illinois, or other states would be interesting knowledge for the pupils of schools in these respective states.

13. How do railroads aid in the development of coal mines?

14. Describe how coal is loaded and unloaded from cars, ships, wagons, etc.

15. Describe lump, egg, nut, and slack coal, and mention uses of each kind.

LESSON XXI

STUDY OF A COAL BED

1. What states produce most coal? Which have no coal mines? Locate on a map the great coal regions of the United States.

2. What foreign countries have great coal mines? Which have none? Study a coal map of the world.

Note.—California and Mexico have no large coal mines. Compare their manufactures with those of Pennsylvania and England, where coal is abundant. Explain how the coal supply influences industries.

3. What important substitute for coal is found in California? The locomotives of the Southern Pacific Railroad use crude petroleum for fuel.

4. Why is coal always found in "beds" or "seams," while other minerals are found commonly in "veins" or "pockets?"

A FIELD LESSON.—To aid in understanding how coal is formed, visit a pond or swamp where flags, cat-tails, bulrushes, and other rank vegetation die down every year and form a layer of vegetable matter over the muddy bottom. Study the pond and follow the changes that take place in the plants that grow near its margins.

5. What conditions are necessary for a pond or marsh to exist? What must be the shape of the earth there? Is it on high land or low land?

6. What kind of bottom must it have? Would a gravelly, porous bottom answer? Why?

7. What must be its water supply? Is it muddy or clear?

8. Can you tell if the pond is growing larger or smaller?

Experiment.—Dig with a spade, or with a garden trowel, into the layers of vegetable matter, and note the changes in condition and color as you go deeper. Account for these changes. Take a section to school to study. When dried, see if any portion of it will burn.

9. Tell how peat is formed and used. Study samples of it.

10. Suppose that instead of flags, rushes, etc., dying and forming layers of peat, there were dense forests of trees shedding their tons and tons of leaves at short intervals and their

immense trunks from time to time, making a great layer of vegetable matter; and suppose that through the sinking of the earth's crust great quantities of dirt should be washed into it and should cover it under a great pressure, what effects would be produced?

11. Find out, if you can, if coal beds generally have gravel or clay under them. Describe the rock called "mother of coal" by miners.

12. What kind of rock usually covers coal beds? Is it formed in layers as if deposited by water?

13. Do the surroundings of a coal bed give evidence of having once been the bottom or margin of a swamp?

Note.—Peat, lignite, bituminous coal, anthracite coal, and graphite all are supposed to have a common origin, their differences being due to the different degrees of pressure, heat, and age through which they have passed. Examine carefully samples of each.

LESSON XXII

COAL MINES AND MINING

To THE TEACHER.—Unless the school is in the vicinity of some kind of mining activity, it may be difficult and unprofitable to give this lesson. Where conditions arouse it, however, children show a wonderful interest in mining and can easily understand most of its operations. A description by a practical miner, good magazine articles on the subject, and good pictures showing workings, etc., will all aid in making clear conceptions.

1. If possible, visit a coal mine and study it.

2. How do miners know where to look for a coal bed? Are gold or silver mines usually found in such places?

3. Are coal seams always near the surface?

COAL MINERS AT WORK

4. Are they always level? What may have changed their position?

5. Describe ways of reaching the coal.

6. When the coal seam is reached, is all the coal removed as the mine is developed?

7. What precautions are taken to prevent the mine from caving in?

8. How is fresh air supplied to the miners?

Note.—Often two shafts, or wells, are sunk on opposite sides of the workings. A hot fire at the bottom of one of these will make the air in it rise rapidly, thus drawing the impure air out of the mine, while fresh air flows down the other shaft to take its place. This current of air is made to circulate through all the passages in the mine. A more expensive way is to pump the air into the mine with machinery.

9. How is the coal broken away from the seam? Describe drilling and blasting.

10. How is it conveyed to the surface? Describe mine cars and their uses.

11. What are some of the dangers to the miners of coal?

12. What precautions are taken to protect the men?

13. How are the various sized lumps of coal separated?

14. How is the coal loaded on the cars? Describe a coal car and the methods of unloading.

15. What can you say of the importance of this industry?

LESSON XXIII

CHARCOAL AND COKE

1. Examine samples of charcoal and coke. In what respects are they alike? In what respects do they differ?

2. For what is charcoal used? When burning, does it give off smoke? What can you say of the heat that it makes?

3. For what is coke used? How does it compare with coal and charcoal in the smoke and heat that it gives off?

4. If possible, visit a charcoal burner's camp and study and describe the way charcoal is made.

Experiment 1.—Place some small bits of oak or other hard wood into a common clay pipe, and close the bowl with clay or plaster of paris. Heat it very hot and test the gas that escapes from the stem with a flame to see if it will burn. When this gas ceases to pass off, cool and open the pipe and tell what changes have taken place in the bits of wood.

5. Why did not the wood burn? What is the difference between burning and what did take place?

Note.—Charcoal is made on a large scale by arranging a great number of pieces of hard wood into a cone-shaped heap, which is covered first with a layer of straw and then with a thick covering of turf. Several

small holes are left around the bottom and a larger one at the top. The pile is then ignited and burns slowly until the whole mass is highly heated. The holes are then closed and the pile allowed to burn and smoulder for several days. When the fire goes out and the pile cools, it is opened, and the wood, now turned into charcoal, is found in the same position as placed in at first.

Experiment 2.—Place powered soft coal in the pipe and treat it the same as in Experiment 1.

6. Compare results in the two experiments. Why is the air kept away from the fuel?

7. Visit the gas works where both coke and gas are made.

8. What other products come from coal?

9. Visit coke ovens, if possible, and learn how coke is made in great quantities for commercial purposes.

LESSON XXIV

THE MOON

1. Study the moon for a full month with care, and record in some manner your observations. This work will have to be done mostly after school, but will take only a few moments each evening. Begin the work at the time of new moon.

2. Where is the new moon first seen? At what time of day?

3. Did you ever see the new moon in any other part of the sky? at any other time of the day?

4. In what direction do the horns of the new moon point? Did you ever see them point in any other direction?

5. Is the new moon seen each evening in the same position in the sky at the same hour?

6. Notice the time the moon goes down each night. What change in time do you notice?

7. Compare its position with respect to the horizon and stars from night to night, and find out if it is moving, and if so in what direction.

8. Is it changing in size and shape? Describe any changes noticed.

9. Can you see the "old moon in the new moon's arms"?

10. How long does it take the new moon to increase to the first quarter?

11. Where is the moon at sunset when in its first quarter? Where was it at sunset when a new moon? Through how many degrees has it passed since then? Trace with the finger the path it has passed through the sky.

12. How long does it take the new moon to become "full"?

13. Where is the full moon at sunset? Did you ever see a full moon any where else at sunset? How many degrees has the moon now traversed since it was new?

14. Note its time of rising. How much later does it rise each night than on the preceding one? How does this compare with its time of setting when it was new moon? Account for this change in time.

15. How long does it take the moon to get into the "dark of the moon"?

16. How many days have we no moon?

17. Watch for the new moon again. What is the length of the moon's cycle?

18. Foretell the moon's phases for the next month; for three months.

19. Explain how these predictions can be made and put in almanacs a year in advance and come true.

LESSON XXV

VEGETABLE FIBERS

1. Recall some of the work done in the Third Grade on the distribution of seeds. What agent in nature scatters most seeds of wild plants?

2. How do wild plants secure the aid of the wind in distributing their seeds?

3. Compare the seeds of the dandelion, the milkweed, and the cotton plant in this respect. Samples of all these should be found in the school cabinet.

4. Describe the appendages of each and how the the wind acts upon them in moving the seeds. From the plant's point of view, what is the value of such an appendage?

5. Which of these appendages to seeds is best adapted to man's use? Examine carefully the structure of each kind.

6. Do you think the fibers on the cotton seed were as long and fine in its wild state as they are now in the kinds that are cultivated? What effect has cultivation on all kinds of plant life?

Note.—By proper cultivation and selection of seed for many years, the cotton plant has changed wonderfully. The fibers are now longer, finer, and more numerous than even the cultivated varieties were a generation ago.

7. Examine samples of cotton in different stages of growth.

8. Describe the cotton plant and the methods used in its cultivation.

A few cotton seeds should be planted in the school garden in the spring and their growth watched. In the colder states the seeds may be planted in pots in the house and trans-

planted to the garden when the danger of frosts is past.

9. How is the cotton separated from the seed? Compare modern methods with those used a generation ago.

10. Give an account of the invention of the cotton gin and its wonderful effects upon the cotton industry.

11. Explain its action.

12. Visit a cotton factory and observe the processes of carding, spinning, and weaving the product of this wonderful plant.

13. How many bales of cotton are raised a year in the United States? Which state produces the most? Which variety is best?

14. What is the average price of cotton in the bale?

15. Who buys our cotton? Where is most of it made up? Why is it not manufactured in the states where it is raised?

16. How do the present prices of cotton cloth compare with those before the cotton gin was invented?

17. Card and spin some cotton by hand and weave into simple mats, etc. Notice how well the fibers are adapted to the many uses made of it by man.

18. What other plants produce useful fibers? Make a list of them.

19. Describe the flax plant. Where is it raised? What part of the plant produces the fiber?

20. How is the fiber separated from the rest of the plant?

21. What is made from the fiber obtained from flax?

22. In like manner tell all you can about hemp, jute, agave, manila, and other plants that yield useful fibers. Tell where each is raised; describe how it is cultivated, and how the fiber is obtained. If possible, obtain a sample of each kind of fiber and tell for what it is used.

23. Which most nearly resembles cotton when manufactured? How may we tell cotton cloth from linen cloth?

LESSON XXVI

ANIMAL FIBERS

1. Mention all the useful animal fibers you can think of. Make a list of them.

2. Bring samples of each to the class.

3. Examine carefully samples of hair, wool, fur, bristles, silk, etc., noting the color, length, and texture of the fibers and learn to distinguish each by its appearance.

4. Examine with a microscope the different fibers and describe the structure of each.

5. Make a list of the animals that bear hair; another of those that bear wool; and a third, of those that bear fur.

6. How do these classes compare in size? Can you see an adaptation in the size of animals and their kind of covering?

7. Do the best furs come from large or small animals?

8. How are the various animal coverings adapted to meet the conditions of climate?

9. What other needs of animals are provided for in their coverings?

10. In what ways do men make use of fibrous animal coverings? What things are made from them?

11. Make a list of articles made from hair; from wool; from fur; from silk.

12. Describe processes used in the manufacture of the various animal fibers. If possible, visit a woolen factory; a silk factory; a hat factory.

13. What animal fibers are not used by man?

14. What animals produce a fiber for their nest or shelter?

15. For what purposes do many spiders produce a strong fiber? Observe the many uses they make of their web and find out how it is produced.

16. Which do you think are more useful to man, animal fibers or vegetable fibers?

LESSON XXVII

CHEMISTRY OF DYEING

Experiment 1.—On a pane of glass mix together some iron filings and powdered sulphur.

1. How may they be separated? Does their difference in weight suggest how they may be separated? Would a magnet aid us? Separate them.

2. Has either substance undergone any change? Define a mixture.

Experiment 2.—Pour some sulphuric acid over some iron filings Heat gently until the filings are dissolved. Pass the liquid through filter paper and evaporate it.

3. What change have the filings and acid undergone? The crystals produced are called *sulphate of iron* or *green vitriol.*

Experiment 3.—Repeat the second experiment, using bits of copper instead of iron filings.

4. What is the difference between what happened in the first experiment and the others?

Crystals of *sulphate of copper* or *blue vitriol* will be formed. When two things unite so as to form a new substance, different from either, it is called a *chemical change.*

5. What is the difference between a mixture and a chemical change or combination?

6. Mention several common examples of chemical changes.

7. How is "hard" water rendered "soft" by using lye or soap powder? Account for the dark scum that is formed.

8. How is soap made and from what materials? How do we make soda water?

9. Account for the milky appearance of limewater when the breath has been passed through it. (See Lesson 13).

The carbonic acid gas in the breath unites with the lime and forms small particles of carbonate of lime (chalk) which float in the water. This is called *precipitate.*

Experiment 4.—Add a few drops of ammonia to a weak solution of blue vitriol.

10. Account for the deep color produced.

Experiment 5.—Dip a rag in a solution of blue vitriol and let it dry; then drop it into a solution of ammonia and dry it again.

11. Account for the color produced. See if the color fades when washed.

12. Add water to the dark blue solution, Experiment 4. Little change is produced. Add a few drops of sulphuric acid. Why is it turned clear?

When a colored precipitate is formed in the fibers of cloth, we say it is dyed. If the precipitate will not dissolve in water, the cloth will wash.

13. What common things will take out color or make things fade?

14. What common things stain clothes?

Note.—Many different colors are made by uniting different chemicals. If the colors are pretty and durable and do not injure the cloth, they may be used as dyes.

LESSON XXVIII

THE SHEEP INDUSTRY

1. Describe a sheep. What do you know of its disposition?

2. What are its chief enemies? What means of defense has it?

3. Why do sheep naturally go in flocks? How do they act when they are frightened? Tell what you know of their habits.

4. What foods do they eat? How does this influence the profits of the sheep industry?

5. Which eat off the grass closest, sheep, horses, or cows? Examine their teeth and notice how each eats.

6. How does the tramping of a large herd of sheep affect the grass under their feet?

7. Visit a sheep camp. Describe a sheep wagon. Tell what you know about a sheep herder's life and labors.

8. Why are sheep kept out of national forest reserves or allowed to graze therein only under restrictions? What harm do they do to young trees?

9. What plants do they eat that other animals will not eat and that would, otherwise, be valueless to man?

10. What states produce the most wool? What are the natural advantages in these states for sheep raising?

11. How many pounds of wool will an average sheep propuce each year? At 20 cents a pound, what will a fleece be worth?

12. A herd carefully cared for will increase in numbers

what per cent in a year? Each ewe sheep has one lamb and many of them two every year.

13. If it costs 50 cents a head to care for the sheep a year, what would be about the profit on 1,000 sheep in a year?

14. If the winter is a hard one and the sheep have to be fed hay, how will this affect the profits?

16. When are the sheep sheared? Why?

17. If the weather turns cold just after shearing the sheep, what loss may occur?

18. What wild animals often kill sheep?

19. What diseases afflict them and injure the wool?

20. Where is most of the wool that is raised in this country manufactured?

SOUTHDOWN RAM

LINCOLN RAM

AMERICAN MERINO RAM

LESSON XXIX

THE SHEEP INDUSTRY (Continued)

1. How many breeds of sheep can you recognize? Study the different varieties at the state fair sheep exhibit.

CHEVIOT RAM

HAMPSHIRE-DOWN RAM

OXFORD-DOWN RAM

SHROPSHIRE YEARLING

2. Which breeds have long wool? Which have fine wool? Procure samples of as many kinds of wool as you can for use in school.

Note.—The different breeds of sheep are often classified by the fineness and length of their wool. The Merino, the Delaine, and the Ramboulette are fine-wooled sheep, while the Southdown, Shropshire, Oxford, and Cheviot have medium wool. The Cotswold, Lincoln, and Leicester are long-wooled sheep. All these kinds of wool are valuable for the different fabrics into which they are made.

3. Are sheep raised for anything besides wool?

4. Are all breeds equally good for mutton? Which make the best mutton?

5. Is the wool from the mutton sheep as valuable as that from other varieties?

6. What is needed in a good mutton sheep?

7. Where are most of our sheep sold and converted into mutton?

8. Describe the shipping of sheep over a railroad.

9. How are they dressed for market?

LESSON XXX

THE CATTLE INDUSTRY

1. What states produce most cattle?

2. In what countries of the world is stock raising an important occupation?

3. What conditions make the cattle industry profitable? Consider climate, vegetation, ranges, markets, means of transportation, breeds of cattle, etc.

4. Compare the advantages and disadvantages of raising stall-fed and range cattle.

5. Tell what you can of the life and labors of the modern "cow-boy." What care should cattle receive on the range?

6. Where are the great cattle ranges of the United States?

7. What breeds of cattle are most profitable to raise on the range? Why?

8. What breeds require the greater care of the farm? Why?

9. Describe the leading characteristics of the breeds mentioned and get pictures of each. Show how each is adapted to the life it leads.

10. To what dangers are cattle subject on the range? What are their chief enemies?

11. Why do some states pay a bounty to anyone killing certain wild animals? Name some of these wild animals.

12. Why are cattle often dehorned?

13. Describe a stampede of cattle.

14. Do cattle ever eat poisonous vegetation and get sick or die from its effects?

Note.—This danger was so great in early pioneer days that people from the eastern states, moving to the far west, were accustomed to

exchange their cattle when they reached the borders of the great prairies for others that were acquainted with the plants there and therefore would not eat the poisonous ones. It seems that by experience the cattle learn which plants to shun.

15. Why does the government provide inspectors to examine all cattle that enter or leave our country?

16. Why are all animals that are used for food carefully examined at the stock yards before being killed?

17. What is the most profitable age to sell beef cattle?

18. What would be the increase of an average herd of cattle each year? Which increase most rapidly, cattle, sheep, or horses? Which do you think would be most profitable to raise? Why?

19. Cattle are now raised chiefly for what two purposes? Why are oxen no longer used to do labor for man?

20. What cities are the chief markets in our country for beef cattle? Why?

21. Why are dairy cattle more widely distributed among the people?

22. Describe the shipping of cattle from the range to the stock yards in the large cities.

23. When different herds of cattle feed for months on the same range, how can the owners separate them?

24. Describe a "round up" of cattle. Why is it necessary to "round them up" occasionally?

25. Describe the branding of cattle. When and why are the cattle and horses branded? Describe a "branding iron."

26. Are sheep often branded with a hot iron? Why? Suggest a good way for marking sheep without causing them pain. Describe how the ears of animals may be cut to denote ownership. Draw various ears marked for this purpose.

Photo. by L. C. Snow

MARKING SHEEP WITH PAINT

27. Do you know of other ways of marking animals?

28. Why do cattle-men object to having herds of sheep come on the ranges occupied by their cattle?

29. Mention plants that are eaten by the cattle on the ranges, during the summer; during the winter.

30. Do herds change their feeding grounds often? Why?

31. During what season is the feed most abundant in the mountains. When is there little to be had there? Why?

32. Compare the movements of herds to the migration of wild animals.

33. How may a severe winter affect the cattle on a range?

34. How may a very dry summer affect the cattle industry?

Note.—The author has seen the plains of Texas strewn with the carcasses of cattle that died of hunger and thirst, during a severe drought, creating a great stench, and leaving for years afterward their bleached bones as a silent witness of their suffering and death.

LESSON XXXI

THE DAIRY COW

1. Cattle are raised, chiefly, for what two purposes?
2. Describe a typical dairy cow.
3. Why is a good dairy cow rarely fat?
4. Does the dairyman wish his cow's food to go to flesh? Why?
5. Why should the dairy cow's udder and milk veins be large? What other features indicate a good dairy cow?

A Typical Dairy Cow

Note.—A good dairy cow generally has a wedge-shaped body, a small head, large mouth, and a large stomach. The hip bones and tail bones are prominent; the thighs are thin and poorly fleshed. The back is narrow and little flesh covers the shoulders, while the neck is

long and slim. Though angular in features and rarely fat, the dairy cow is often pretty and some breeds are even graceful.

6. Would such a cow be adapted for beef? Why not?

7. Why are most of those features desirable in a dairy cow? What disposition should she have? Why?

8. Mention several good breeds of dairy cows.

9. Visit a dairy. Notice the care and cleanliness in feeding and milking the cows and in handling the milk.

10. How much milk will a good cow give in a day? During how many months of the year will she give milk?

Note.—The Jersey breed is one of the best for dairy purposes. A good Jersey cow will produce 6,000 pounds or more of milk in a year. In exceptional cases cows have produced several times that amount.

11. If it costs 15 cents a day to keep a cow, and 2 cents a quart to deliver the milk, what is the profit in a year on a good dairy cow at the price you pay for milk, if a quart weighs 2 pounds?

LESSON XXXII

BEEF CATTLE

1. What are the chief points needed in beef cattle?

2. Wherein do they differ from dairy breeds?

3. Do good beef breeds give much milk? Why?

4. Learn to judge the points of excellence in both types. What breeds can you recognize at sight?

Note.—The beef type generally has a square, heavy-set body, with much flesh on the backbone, shoulders, and thighs. It is more hardy than the dairy type and is often kept in great herds on the prairies throughout the year at small cost.

5. Why are these features desirable in beef cattle? Are they needed in dairy cows?

6. Compare the expense and profits of raising each kind.

7. Name several good breeds of beef cattle.

Note.—The Galloway, Shorthorn, Angus, and Durham are favorite breeds of the beef type. Compare them with the Jersey, Guernsey, and Holstein—examples of the dairy type. If living animals cannot be seen, study good pictures.

8. In what states are most beef cattle raised? Why?

9. Why are dairy cows not confined to certain localities, but found in all the states?

10. Is it profitable to raise common, or scrub, cattle for either purpose? Why not?

11. Where do the excellent breeds mentioned in this lesson come from? What influence will care, food, and proper selection have in improving breeds of cattle?

Note.—The best breeds have come from the wild oxen of Europe and Asia. The treatment given them by man for many generations has developed from those inferior animals the modern excellent breeds of cattle.

11. Give a description of a cattle ranch.

12. What conditions are necessary for a successful ranch? Consider the value of the land, food and water supply, climate, market, etc.

14. At what age are beef cattle marketed? Why?

15. What is the average price paid for a beef steer two or three years old?

16. What do you know about the size of the herds of beef cattle and the cost of their care?

17. Tell what you can about how the beef is prepared for market at the stock yards.

18. How is beef shipped on land? on water?

GUERNSEY

AYRSHIRE

JERSEY

GALLOWAY

HEREFORD

SHORT HORN

19. Why is each quarter labeled with the beef inspectors' certificate?

20. What foreign countries buy great quantities of beef from the United States? Why do they not raise what they need at home?

21. Visit a meat market and learn the names and prices of the different cuts of beef; and from what part of the body each cut is taken.

22. What cuts are roasted? fried? boiled? stewed?

23. Which are costly? Which are cheap? Suggest a reason for the price in each case.

24. How is meat preserved from spoiling for shipping or for future use? Describe methods of cold storage; of canning, drying, pickling, etc.

25. Mention all the useful products besides meat and milk that are obtained from the cow. Make a list of them and tell all you know about the manufacture and use of each.

TO THE TEACHER.—A number of lessons may be given to the consideration of the following products; or one may be assigned to each pupil to study and to report to the class all he can find out about it from personal observation, from inquiry of those who know about it, or from newspapers or books in the library. Consider each article, its method of manufacture, and its various uses: Hides, horns, tallow, hoofs, hair, glue, gelatine, neat's foot oil, celluloid, bones, fertilizers, etc.

LESSON XXXIII

RANGES AND THE NATIONAL FORESTS

1. In what part of the United States are the great ranges?

2. What is their chief use to man? What plants grow on them?

3. Which of these plants furnish food for cattle, horses, and sheep?

4. What plants are these animals liable to destroy?

5. What are forest reserves, or national forests?

6. What is the object of the government in taking charge of the great forest regions of the west and restricting lumbering, grazing, etc.?

7. How is grass affected by over-grazing?

Large tracts of the best grazing lands have been made as barren as a desert by over-grazing.

8. How does the eating of all the grass influence the growth and scattering of seeds for another crop?

9. Why is there little or no grass in a footpath? What effect will the tramping of the feet of large herds have upon the growth of all kinds of grass?

10. If the grass, growing in the midst of a young forest, is eaten off too closely, what harm will the animals do to the young trees if allowed to remain there?

11. In what way is a grown forest sometimes destroyed through the carelessness of herders or campers?

12. Tell of great forest fires of which you have heard. How do you think such fires are started?

Note.—Large forests of timber, whose value could hardly be told, have been burned, through leaving a camp fire smouldering, or by dropping a lighted match or cigar among dry leaves or grass. Railroads, houses, and even towns in or near these forests also have been destroyed by these fires. Michigan, Wisconsin, and Minnesota particularly have suffered from this cause.

13. What precautions are now taken to prevent forest fires?

14. How have these fires influenced the supply and price of lumber in the United States?

15. What do you know of the duties of forest rangers?

16. What punishment is given to those who start forest fires, or break the regulations made by the government to prevent them?

17. Will over-grazing do any damage besides killing young trees and destroying the pasturage?

18. How do plants influence the flow of water down the watersheds that supply our mountain streams and rivers?

19. In case of a heavy rainfall, or a rapid thaw of snow piled away in the mountains, how will the flow down a naked slope compare with that of one down a slope covered with grass and leaves and shrubs?

20. In which case would a destructive result be most probable? In which case would most soil be washed away and silt carried down?

21. What damage is sometimes done by floods?

22. What damage is often done to reservoirs and canals made for irrigation by the silt that is brought into them in the time of high waters?

23. Can you think of any other reasons why grazing on public lands should be properly regulated?

24. Should it be stopped entirely? What would be the effect upon our supply of beef, wool, and other products of the live stock industry?

25. Why will reasonable grazing do little harm?

LESSON XXXIV

HUNTING AND TRAPPING

1. What animals are hunted for sport in your vicinity?

2. Are any hunted because they are harmful to man?

3. Name the principal game animals. Make a list of them.

4. Discuss each one, considering the following points: (a) What is its food? (b) When and where does it rear its young? (c) Is its flesh good for food? (d) Is it harmful or useful to man? (e) Is it numerous or scarce? (f) What are its habits? (g) How is it killed or trapped? (h) Is it a good thing to kill such animals?

5. Describe methods of hunting bears. What means is commonly used to kill them? What are the bear's methods of defense? What is the food of the bear? Is its flesh good for food? What danger is there in hunting these animals? What harm do they do? Ought they to be killed?

6. Consider in like manner how to hunt the deer, wolf, fox, rabbit, goose, turkey, duck, grouse, quail, and other game animals.

7. Describe the bow and arrow, spear, sling, shotgun, rifle, and how each is used in hunting and what care and precautions should be taken in its use.

8. What animals are often secured by trapping?

9. Describe traps suitable to catch mice, rats, beavers, wolves, bears, birds, fishes, etc. Make a trap to catch some animal found in your vicinity.

10. Consider the habits of the animals mentioned and how and where traps are set to catch them.

11. Describe snares for catching birds. What birds may be caught in this way? Make a bird snare.

12. Should any animal be killed simply for sport?

13. What evidence do animals show that life is dear to them?

14. What useful animals are often killed "just for fun?"

15. What animals have almost disappeared because of this cruel habit of man?

16. Why are there game laws to control and restrict the killing of certain animals?

17. Why is a bounty paid for killing certain animals? Mention animals that are protected by law, and some that the law seeks to destroy. Give a reason for the provisions of the law in each case.

18. What do you know about old time methods of hunting and trapping?

LESSON XXXV

FISH AND FISHING

1. Mention all the fishes you know that are found in the local streams. Make a list of them. Describe each.

2. Which of these are native? Have any of them been imported and placed in the streams?

3. Visit the fish market and learn the names of the fishes offered for sale and where they come from.

4. Which come from the ocean? Which from rivers? Which from lakes?

5. Are any fish found in Great Salt Lake? Why not?

6. What foods do various fishes eat? Tell the food eaten by each kind of fish named on your list.

7. Are all kinds of fish suitable for food? Which kinds do you prefer?

8. What do you know of the habits of fishes? How do they get their food?

9. How do they increase?

Note.—If possible, visit a fish hatchery and see the spawn and young fish in various stages of growth. In a natural state the female fish will swim up stream or to a safe quiet place and there deposit her eggs, usually in great numbers. She then goes away and probably will never see one of her own offspring. When the young is first hatched, it is kept alive on the extra food contained in the egg from which it came until it grows large enough to hunt food for itself.

10. Give a reason for the shape of the fish. How many fins has it? Name each fin and tell how it is used.

11. How do fish escape from their enemies? Are any protected by their color?

12. Did you ever try to hold a live fish in your hands? Why is it so slippery? Of what use are its scales?

13. Tell how a fish swims. How does it rise or sink at will in the water?

14. Mention different methods of catching fish. Describe how fish are caught with a hook and line. What is used as bait? When a fish "bites," how is it landed?

15. How is a net used in catching fish? Describe a seine and how it is used.

16. Have you ever been on a fishing trip? If so, describe it.

Photo, by L. C. Snow

TROUT FISHING

17. Describe a fish trap. How are the salmon caught that are used in the large canneries of Columbia River?

20. Describe the great cod fisheries.

21. Are any kinds of fish protected by law? In what way? Why? Tell what you can find out about the fish laws of your state.

22. Should dynamite or other explosive be used in killing fish? Why?

23. How do fish breathe? What are their organs of breathing called?

24 At live fish shows, why is a stream of water made to flow rapidly into the fish tank?

25. In what ways are fish useful to man?

26. How does the government aid in keeping our streams and lakes supplied with the best kinds of fish?

LESSON XXXVI

SHELLFISH

1. Obtain, for study, samples of shellfish such as the clam, oyster, crab, lobster, crawfish. snails, shrimp, etc.

2. Which of the samples obtained are fit for food? Which are not?

3. Which move about? How do they move? Which cannot move about?

4. Compare their different coverings as to shape, hardness, size, thickness, color, structure, and uses.

5. Which shellfish have the color of seaweeds? of sand? Why?

6. Which have the hardest, strongest coverings? Why?

7. Which shells are made up of two parts? How are they joined?

8. Which shellfish live in salt water? Which are found in fresh water?

9. Tell how each is protected from its enemies?

10. As shellfish increase in size, which cast their shell and which increase the size of their shell?

11. Are any of their shells used by man? If so, for what purpose?

12. What kinds of shellfish are most common in your vicinity? What can you say of their numbers?

13. Are any of them harmful to man?

14. Which are cultivated by man?

15. What food do they eat and how do they contrive to get it?

16. Make a special study of the oyster and give an account of its life's history; how it is cultivated by man, and the different ways in which it is used.

17. Collect the shells of as many shellfish as you can and group them into classes according to their shape and structure.

LESSON XXXVII

BUILDING STONES

1. Mention all the building stones that you know. Bring to school samples of the different kinds.

2. Learn to recognize them at sight; where they are obtained, the properties that make them valuable, and the different uses to which they are put.

3. Describe sandstone. Why is it so called? Examine it with a lens. Where is it obtained? Is it easily worked? Does it have a cleavage that makes it easy to split into regular

shapes? Will it receive a polish? In what colors is it found? Is it durable? How can you tell? Mention buildings in which sandstone is used. What parts of a building may be made of sandstone?

4. Answer similar questions about other common stones used in buildings, such as granite, limestone, marble, onyx, etc.

5. Visit a stone yard and learn how great stones are cut into smaller ones and into various shapes, and how they are surfaced and polished.

6. If possible, visit also a stone quarry and see how great mountains of stone are split into large blocks to be shipped to stone yards or to buildings that are being erected.

7. What stones are used chiefly for ornaments?

8. Name such as will receive a high polish.

9. Which owe their value to their beautiful markings?

LESSON XXXVIII

PROPERTIES OF MINERALS

TO THE TEACHER.—Throughout the year the pupils should be encouraged to procure samples of as many different kinds of minerals as possible; these should be preserved in a suitable cabinet. Every mineral taught should be taught with the aid of a sample of it, and the work suggested here should be modified according to the minerals on hand with which to illustrate it.

1. Name at sight each mineral specimen at hand.

2. Put into groups those that seem to resemble each other in structure and looks.

3. What is one of the first qualities we think of as be-

longing to minerals? Whence comes the common comparison "as hard as a rock?"

4. Are all minerals equally hard? Test samples.

5. Arrange the samples according to their hardness. Which is the hardest sample? Which is the softest?

6. Mention other minerals you may know that are hard; that are soft.

7. How should each of these be classed as to its degree of hardness—chalk, glass, soapstone, shale, marble, talc, limestone, brimstone, emery, lead, steel, etc.?

8. Which of these minerals are very hard? Which are very soft?

Note.—Minerals are divided into ten degrees of hardness, the diamond being the hardest. Chalk and talc can be scratched easily with the finger nail and are said to be very soft. Five degrees of hardness will serve our purpose; very hard, hard, medium, soft, and very soft.

9. Classify the samples into these five groups, as best you can.

10. What difference do you notice in the weight of minerals? What minerals are very heavy? Which are light?

11. Arrange the samples into five groups according to their weight, as you can best judge them.

12. What minerals are valuable because they are hard? because they are soft? because they are heavy? because they are light?

13. Mention minerals that are black, white, blue, gray. What other colors are seen in minerals?

14. What use is made of colors found in minerals?

15. What paints are colored with mineral pigments?

16. What minerals are clear or transparent?

17. Which are not quite clear or translucent?

18. Which are opaque and allow no light to pass through them?

19. What property gives glass its chief value? Can you think of other minerals that are valuable because of their action with light?

20. What minerals are tough? Which are brittle? How do these properties add to the value of certain minerals?

21. Which can be hammered into thin layers? State uses of this property?

22. Which can be drawn into wire? What metals are useful on this account?

23. What minerals will bend and spring back into their former position? How is elasticity useful in minerals?

24. Make a list of all the properties of minerals that you have learned.

LESSON XXXIX

ORES AND SMELTING

1. Collect samples of ores—iron, lead, copper, silver, gold, etc. Examine them and note their color, weight, and general appearance.

2. Learn to tell at sight the probable chief metal contained in each sample.

3. What color indicates the presence of iron in ore? What color indicates copper? lead and silver?

4. What effect has great heat upon many common minerals?

5. Have you seen glass melted in the stove? Where do the clinkers found in the furnace grate come from?

6. What stones in nature show the action of fire? Examine

samples of lava, porphyry, pumice stone, etc., and compare them with sandstone, shale, etc.

Experiment 1.—Heat a small, thin piece of limestone in the flame of an alcohol lamp. Note the change produced in color, structure, etc.

Experiment 2.—Pulverize a piece of galena; mix with it a small quantity of bicarbonate of soda, and put the mixture into a shallow cavity in a piece of charcoal. Melt it with the flame of an alcohol lamp and a blow pipe, and a piece of lead may be obtained.

7. How are ores melted on a large scale and the metals taken out?

8. If possible, visit a foundry and see how iron is melted and cast; or, better still, visit a smelter where ores are melted and the metals are separated from them.

FIFTH GRADE—SPRING WORK

LESSON XL

A PROBLEM IN GARDENING

TO THE TEACHER.—As early as the weather will permit, have the pupils prepare a portion of the school garden for the planting of radishes. A good problem for the class to solve is how to raise radishes for the market most profitably. Consult seed catalogues.

1. What are the chief elements for success in raising radishes for the market?

2. How does the price of early radishes compare with that of late ones?

3. What qualities in radishes make them most salable? Consider size, shape, color, flavor, firmness, etc.

4. Describe the varieties of radishes that you know about.

5. Does one variety mature more quickly than another?

6. What would be the advantage of planting a variety which matured early?

7. What seed will produce the greatest crop on a given amount of ground? What peculiarities of growth will produce this? Consider size of root and size of leaves.

Experiment.—To determine which of all the varieties offered for sale is best for the early market, and for the later trade, procure seeds of many varieties and plant them in parallel rows, marking properly each row. One end of each row may be planted deep and the other shallow. About three weeks later, if the weather is favorable, the lesson may be resumed. Consider then the following questions:

8. Which variety has matured in the shortest time? Which has taken the longest time?

9. Which has the finest flavor?

10. Which takes the least space and therefore produces most radishes in a row?

11. Which variety is firm and crisp and which is pithy?

12. Which has the most attractive shape? color?

13. Which variety will produce most crops in the year?

14. What radish is best for a market garden?

15. Keep a careful record of each variety planted and learn its good and bad points. If possible, put this knowledge to account by raising a crop for market or home use.

LESSON XLI

CAUSES OF SEASONS

1. Point to where the sun rises now; to where it sets.

2. Where did it rise at Christmas time? Where did it set then?

3. By pointing with the finger, trace the sun's daily path through the sky in September when school began; at Christmas time; at the present time.

4. What gradual north and south movement has the sun?

5. When did the sun reach its southern limit? When will it reach its northern limit? How long does it take the sun to go from one limit to the other?

6. Compare the length of the sun's daily path through the sky in the winter and in the summer. Compare the length of days in these two seasons; the length of nights; the length of the noon shadow.

7. Since the sun stands still and the earth revolves on its axis and in an orbit around the sun, what must be the conditions to make the sun seem to rise and set daily and to move north and south during the year?

8. What other things seem to move, but do not? Recall how things look outside when you are in a car moving rapidly. When on a boat leaving the pier, what motion does the pier seem to have?

9. In what direction is this motion always as compared with your real motion? What is its rate as compared with yours?

10. What movement of ours would make it seem to us that the sun, moon, and stars move from east to west?

Experiment.—Pass a wire through the center of an apple, an orange, or any sphere to represent the earth, and revolve it in the sunshine. Imagine the people to be as small accordingly as the globe is; show how sunrise and sunset are made to appear to them as the sun's motion.

In a similar way, while turning it rapidly on its axis, make the apple pass horizontally around a globe standing on the desk to represent the sun. Let the axis slant in one direction, so as to make the sun seem to be overhead in the northern hemisphere at one place, and overhead in the southern hemisphere on the opposite side of the sun.

Repeat the experiment a number of times with the earth's axis in various positions,—vertical, horizontal, and at different angles, and tell what effect each position would have upon the distribution of light and heat on the surface of the earth.

11. Show by the experiment what would be the effect if the north pole pointed directly toward the sun all the time. What would be the condition at the north pole? at the south pole? at the equator?

12. If the axis were vertical, how would it affect the seasons?

13. The axis always points toward the north star or is bent over $23\frac{1}{2}$ degrees from the perpendicular. How does this give us four seasons in this country? How does this divide the earth into zones?

14. Explain the apparent movement of the sun northward and southward every year.

LESSON XLII

TRANSPORTATION—ITS EVOLUTION

1. Why do we need to move things from one place to another?

2. What do we use in doing this work on land? over water? over snow?

3. What peoples have the poorest means of transportation? Describe how the Indians move their things; how loads are carried in China; in South America.

4. What animals aid man in carrying burdens? Make a list of as many as you can think of and tell how each does its work. Which are adapted to carry loads over dangerous mountain paths? over frozen snows of the north? over the hot and dry desert? in the temperate climes? Give reasons in each case.

5. What things have been invented to aid man in carrying loads?

6. What things have been invented to aid animals in moving freight?

7. How does steam aid us in transportation on land? on water?

8. What other powers aid man in this labor?

9. Explain how each of the following vehicles enables man to carry more freight or passengers; the litter, the wheelbarrow, the cart, the wagon, the sled, the boat. What advantages has each to make work easier?

10. What peoples have only trails and footpaths on which to travel?

11. How do good roads affect transportation?

12. Tell how good roads are made and paid for. Consider the laying out of roads, the grading, turnpiking, graveling, and paving of roads, in both country and city.

13. Why are steel roads needed for cars? How are they made?

14. Compare modern roads and means of transportation with those of olden times, and trace the steps in improving them.

LESSON XLIII

TRANSPORTATION—THE LEVER

TO THE TEACHER.—The simple mechanical powers can be taught children much better in connection with devices wherein they are used than in an abstract way; and since the children are interested in the vehicles of transportation, the study of this subject will serve the double purpose of teaching a most important human activity and the first principles of mechanics.

Experiment.—Make of wood a small, three-sided prism to be used as a pivot, or fulcrum; and a thin, smooth strip of wood for a lever, which should be marked off in inches. A common ruler or yardstick will do. Balance the lever over the fulcrum and, using small nails or flattened buckshot for weights, work out the following problems:

1. When equal weights are placed at equal distances from the fulcrum and on opposite sides of it, how does the lever act?

2. When they are placed at unequal distances from the fulcrum, how does the lever act? Which end rises? Why?

3. If unequal weights are placed at equal distances from the fulcrum, how does the lever act? Why?

4. Can you place unequal weights where they will balance each other on the lever? Compare the difference in the weights and the distances from the fulcrum and see if there is any relation between them.

5. Where will one weight, six inches from the fulcrum, balance two similar weights on the opposite side of the fulcrum? Where will it balance three similar weights?

6. Experiment in balancing different weights at different distances until a relation, or law, is discovered between the weights and their distances from the fulcrum.

7. If a small weight is to balance a large one, what must be their relative distance from the fulcrum?

Note.—The distance from the fulcrum to either weight is called an *arm* of the lever. In using a lever to do work, the power takes the place of one of the weights and its distance to the fulcrum is called the *power-arm*. The other arm is called the *weight-arm*.

8. Where have you seen levers used to do work? Describe levers and the work that you have seen them do.

9. How much weight can a man raise with a lever six feet long by putting one end of it under a heavy stone and resting the lever over a fulcrum one foot from that end and bearing down 150 pounds at the other end?

10. Find all the levers you can in a wheelbarrow; a cart; a wagon.

11. Find the fulcrum in each case.

12. Explain how each lever found is an advantage.

13. If the length of the power-arm be increased, what effect will this have upon the amount of weight it can lift? If it be made shorter, what will be the effect?

14. If the weight-arm be shortened, what will be the effect? If it be made longer, what will be the result?

To the Teacher.—The exact law of equilibrium of the lever need not be given in this grade, since children are not exact in thought or action, but they should work with the lever and weights until the great principle is discovered. When they can grasp and use it, teach them that the Power times the Power-arm equals the Weight times the Weight-arm.

LESSON XLIV

TRANSPORTATION—THE LEVER (Continued)

Experiment.—Balance equal weights placed on the lever on opposite sides of the fulcrum. Move the lever up and down and measure care-

fully the vertical distance through which the weights move. How do they compare? Repeat the experiment using unequal weights.

1. If one weight 14 inches from the fulcrum balances two weights 7 inches from it on the opposite side, through how much distance will the latter move when the former is raised 4 inches? 6 inches? When lowered 2 inches?

2. In problem 9 in the last lesson, through how much space will the power-arm have to move to lift the stone 2 inches?

3. When unequal weights, balanced on the lever, are made to move up and down, which weight always passes through the greater distance, the lighter or the heavier?

4. When one weight balances another twice as heavy, how does the distance it moves compare with that of the other?

5. When it is three times as heavy, how do the distances compare? Find the results by testing with the lever.

6. Continue to experiment with the lever and weights until the relation between the distance covered by the power and weight is discovered and understood.

7. When the power-arm is longer than the weight-arm, what is gained by using the lever? What is lost? Prove it.

8. When the weight-arm is the longer, what is lost? What is gained? Prove it by using the lever and weights, letting one weight represent the power.

9. How does this relation, or law, compare with the one learned in the last lesson?

10. Tell of a lever you have seen used to gain power, i. e. where a little power moved a great weight or did greater work.

11. Tell of a lever that you have seen used to gain time, i. e.

where the power moved through only a small distance in making the weight move through a greater distance.

12. In using a wheelbarrow, which is gained, power or time?

13. In using a pitchfork, which moves through the greater distance, the power or the weight?

14. In pressing on the pedal of a bicycle, what is gained?

15. In using an oar in moving a boat, what is gained?

16. In "setting" the brake on a wagon, is power or time gained?

17. Think of other levers that gain power. Mention also others that are used to gain time at the loss of power.

LESSON XLV

TRANSPORTATION—KINDS OF LEVERS

1. Is the fulcrum in all levers between the weight and the power? Give examples, if not.

2. Locate the fulcrum, the power, and the weight-arm in the following levers: a wheelbarrow, a pitch-fork, a pedal of a sewing machine, a bicycle, an oar, a wagon tongue, a carriage brake, a windlass, a capstan, a hammer, in drawing a nail, in driving a nail, a crowbar.

A lever having the fulcrum between the weight and power, like the one you have been using, is called a *lever of the first class.*

3. Mention several levers of the first class. What is gained by levers of this class? Give illustrations.

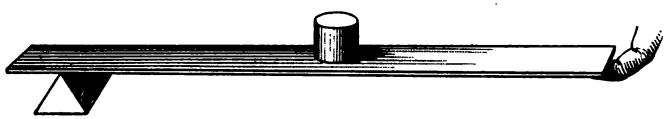
When the fulcrum is at one end, the power at the other, and

the weight is between them, it is *a lever of the second class.*

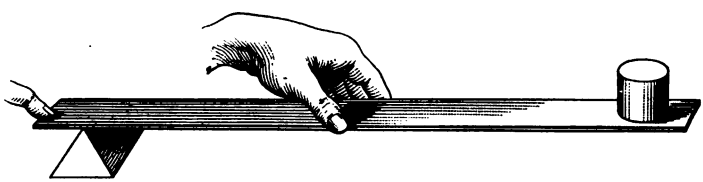
4. Name several levers of the second class. What is gained by levers of this class?

When the fulcrum is at one end, the weight at the other, and the power between them, it is a *lever of the third class.*

A LEVER OF THE FIRST CLASS



A LEVER OF THE SECOND CLASS



A LEVER OF THE THIRD CLASS

5. Mention several examples of this kind. What is always gained by this kind of lever?

6. What kinds of levers are found in the following articles, and what is gained by each—a lemon squeezer, a nut-cracker, a spade in digging, sheep shears, a crank, a can opener, a tack puller?

7. If a father and a son are carrying a weight of 100 pounds between them on a pole 4 feet long, where should the weight hang so that the father will carry 75 pounds?

8. If a bar of bullion weighing 200 pounds is placed on a

wheelbarrow 1 foot from the axle of the wheel, what weight will the man wheeling it have to lift, if the handles are 5 feet from the axle?

9. Mention levers found about carts, wheelbarrows, wagons, street cars, railroad cars, locomotives, boats, shipping, automobiles, bicycles, flying machines, etc.

10. In each case, as far as you can, tell what is gained and what is lost.

LESSON XLVI

TRANSPORTATION—THE WHEEL

Experiment 1.—Try to roll a cube and a ball down the same inclined plane. Which rolls better? Why?

1. Slowly overturn a cube. What movement do all the particles in it have to pass through in turning over?

2. Which takes the more labor, to roll a box of goods across the floor or to wheel it across on a truck? Why?

3. What forms are more easily overturned than a cube? What forms are more difficult to overturn than a cube? Explain why in each case.

Experiment 2.—Overturn a book lying on one cover. Overturn a book that is standing on its end. Which takes the greater labor or force? Why? Overturn a cube and a ball of about the same weight. Compare the force needed in each case.

4. How does the size of the base influence the force needed to overturn an object?

5. What forms are most stable? Why? What forms are most unstable? Why?

6. Compare a wheel with a ball in this respect. What can you say of the size of the base of each?

7. Why are wheels placed under heavy loads that are to be moved?

8. Why should wheels so used be perfectly round? If the wheels were somewhat flattened, what would be the effect upon the amount of force needed to pull the load? Why? Besides going forward, the load would have what other motion?

9. Why are car wheels removed as soon as they get a "flat" side?

10. Why was the invention of the wheel the most important step in the advancement of transportation?

11. Why does a stone in front of a wheel make the load so much harder to pull?

12. Why should roads be smooth and hard?

13. Why do steel rails reduce the power needed by the locomotive?

14. Account for the ease of motion in the "ball" bearings. Examine how a ball bearing is made.

LESSON XLVII

TRANSPORTATION—THE INCLINED PLANE

1. Why do men roll a heavy barrel up a plank into a wagon rather than lift it up?

2. How is the inclined plane an advantage?

3. Give several illustrations of the use of the inclined plane.

4. What effect has it on the power to make the inclined plane very steep? to make it very gentle in its slope?

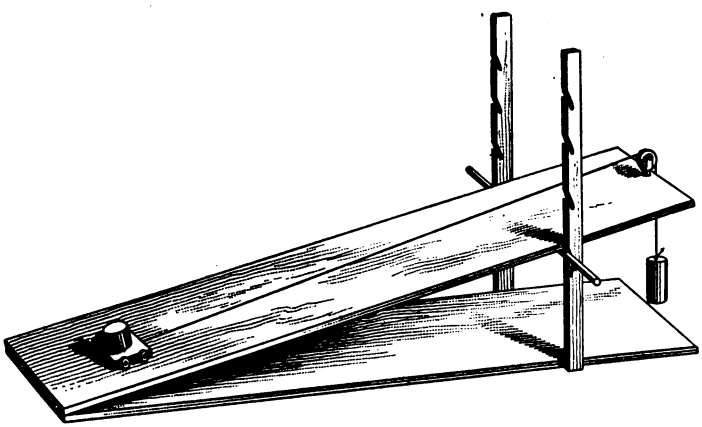
5. Would you rather climb a steep hill or one with a gentle slope? a ladder or a stair?

6. Why do paths and roads seldom go straight up hill?

7. Why are railroads in mountainous regions so crooked?

8. Why can a man on foot climb certain mountains faster than a locomotive can? Which could go through the greater distance in going upward?

Experiment.—Make an inclined plane of two small boards hinged together at one end and separated at the other end by an adjustable support. Balance a small wagon by a weight at the opposite end of a string, which passes over a pulley, as shown in the cut.



Place any given weight on the wagon and adjust the inclined plane at any desired angle. Test the amount of power needed to raise the weight by adding weights to the lower end of the string. Any change in the angle of the inclined plane will cause a corresponding change in the weights needed to balance the wagon and its load.

9. Explain the influence of the slope of the inclined plane to the power needed, and to the distance the weight is raised.

Experiment with this apparatus or with similar devices until their principle is understood.

10. If the power used is not great, what kind of an inclined plane must be used to lift a great weight? While thus gaining power, what is being lost?

11. What is the advantage gained by using the inclined plane?

Note.—The wedge is a double inclined plane and the screw is an inclined plane running spirally around an axis. Both are often used to exert great power.

LESSON XLVIII

TRANSPORTATION—A RAILROAD

To THE TEACHER.—Take the class to a railroad station and call the pupils' attention to the construction and adaptation of all things used there in transportation. No doubt some obliging official or employee will gladly go with you and make needed explanations. Examine the various things mentioned in the lesson, calling especial attention to the use of levers, wheels, inclined planes, light, heat, friction, momentum, and other principles of physics, that the pupils may be able to answer the questions asked in the lesson and others that you may ask them after the visit. Several lessons may be given to this topic.

1. *Cars.*—Describe a common box car. State what you can of its size, openings, number of wheels, brakes, springs, couplings, capacity, uses, etc. In like manner describe a coal car, a cattle car, a refrigerator car, a coach, a sleeping car, a dining car, etc., showing their adaptation to their special uses.

By means of pictures, explain the improvements that have been made in cars, and suggest what changes may yet be made for their betterment.

2. *Trackage.*—Explain how and why a track is graded:

Explain cuts and fills; the use of the ties; the weight and strength of the rails, and how they are fastened down. Describe a railroad bridge; a tunnel; the working of a switch; the use and action of signals, etc.

3. *The Locomotive.*—Where is the fire box? Tell which is the boiler and how the greatest possible amount of heat is obtained. Where is the coal supply? the water supply?

A Locomotive Drawing a Passenger Train

Which are the drive wheels? Why are they so large? Explain the use and action of the bell, the whistle, the throttle-valve, the steam chest, the cylinder, the eccentric rods, the pilot, the cab, etc.

4. Find in the things mentioned above, levers, wheels, pulleys, inclined planes, and applications of other things that you have studied.

5. *Buildings.*—Describe and show the need of a waiting

room, ticket office, telegraph office, bureau of information, baggage rooms, and freight houses.

6. *Employees.* Explain the duties and responsibilities of the engineer, fireman, conductor, brakeman, porter, yard master, train dispatcher, ticket agent, freight agent, manager, etc.

7. At what rate of speed do passenger trains run? freight trains?

8. What are some of the dangers of railroad transportation?

9. What precautions are taken to prevent accidents?

LESSON XLIX

OUR GREAT RAILROADS

1. Mention some of the most important railroads in the United States.

2. Where are they located? Why do many of them follow rivers? Do many of them cross mountains?

3. What has made them important? Are there natural conditions that aid them?

4. How may one go from New York City to Chicago? Over what roads may he go from Chicago to Omaha? from Chicago to Kansas City? Study a good railroad map of the United States.

5. Describe three routes of crossing the continent by rail.

6. Which line first crossed the continent? Why did the government aid it?

7. Mention the most important benefit of railroads to the individual, the town, the state, the nation. Are railroads in any way a detriment?

8. Where are the great lumber regions of the United States?

9. Locate the wheat belt, the corn belt, the cotton belt, the coal regions. Where is most manufacturing done? What states are most populous?

10. How do these things influence the building of railroads?

11. In what part of our country are there no railroads? Why?

12. Why were large cities formerly built near the ocean? Is this equally true now? Why?

13. Where are railroads needed now? What conditions must exist to get men to build railroads?

14. How may the discovery of rich mines of gold or silver influence the building of railroads? Can you give an example of this?

15. Since the war with Spain, why are great companies building lines to the Pacific Coast?

LESSON L

PLANT PROPAGATION—GERMINATION

Experiment.—Plant a variety of seeds in damp sawdust and watch them germinate and grow, noting carefully each step in their development.

1. What is the most common way of getting new plants?

2. Make a list of plants you know that grow from seeds. Which live only one year? Which live many years?

3. What are the conditions necessary for plants to grow from seeds and mature? Recall the work done on Germination (See Book I, page 113).

4. Prove that moisture is necessary to germination. What care is taken of stored wheat, corn, and other grains to keep them from sprouting?

Wheat stored in the dry climate of Egypt has kept 2,000 years in good condition.

5. Prove that warmth is necessary to germination. Why do seeds, planted too early in the spring, sometimes rot in the ground? What kinds may be planted earliest?

6. Why will a late damp spring or an early dry one cause a poor crop?

7. Do germinating seeds require air?

Experiment.—Drop some beans, wheat, or other common seeds into a bottle of water and set the bottle in a warm window for a week or more. Compare the results with seeds sown in moist sawdust or dirt.

8. How does air get mixed with soil? When the water in damp soil evaporates, what takes its place?

9. Do crops usually thrive in soil that is always very damp? Why? Give examples that you have seen.

10. Why is it a good thing for plants that rain is not continuous, keeping the ground wet all the time?

11. What kind of soil is best when there is too much moisture, sandy or clayey soil? Why?

12. Describe each change that takes place in most seeds as they germinate and grow, and account for it.

LESSON LI

PLANT PROPAGATION—CUTTINGS

Experiment 1.—Cut a slip from a geranium, a coleus, a carnation, a poplar, a currant, a willow, a rose, a privet, a grape, an oleander, or

from any other common plant, and set them out in good moist soil. Keep the soil in good condition and watch and record what takes place with the slips.

If the woody slips are too old, they may not grow. This may be told by their looks, and by giving them a quick bend. If they do not break, they may be too young: if they are brittle and splinter, they may be too old: but if they break and hang by the bark, they are in proper condition.

Cuttings having buds should be three or four inches long and be planted so as to leave at least one bud above the ground, and two beneath the surface. Those having joints, as the carnation, should be planted so as to have at least two joints below the surface. If the cuttings have leaves, pull most of them off. Why?

1. Which of the cuttings sprout first? which are slowest?
2. Which cuttings will not grow in this way at all?
3. What plants are commonly grown from cuttings?
4. Would these plants grow as well from seeds? Will they mature and bear flowers or fruit as soon from the seed as from the cuttings?

Experiment 2.—Take some leaves of a cactus or rex begonia and cover them partly with damp soil—especially the part where the leaf is broken off. Note what takes place. Try leaves of many kinds.

5. What plants may be propagated from their leaves?
6. Is this method ever used in the garden or greenhouse?
7. Does nature ever produce new plants from leaves?
8. Do such plants as grow from leaves generally produce seeds?

Experiment 3.—Completely cover with good soil some potato eyes; some onion sets; a few roots of raspberry, blackberry, and asparagus plants. Keep them in favorable conditions and note any changes that they undergo.

9. What plants send up sprouts from their roots?

10. Do any of them depend upon this method alone to produce new plants?

11. Man uses this method with what plants? Why?

Experiment 4.—Select a long, slender, branch of a Virginia creeper, grapevine, rosebush or other common shrub growing near the school, and bend it down to the ground and carefully cover a section of it with three or four inches of soil. Leave a foot or more of the end of the branch above the ground and do not cut the branch from the parent plant.

12. What takes place at the buried portion? When may the branch be cut from the parent stem without killing the new plant?

13. This method of *layering* has what advantage over simply putting slips or cuttings in the ground to grow? Why?

14. What plants have you seen produced by layering them?

15. Observe all common wild plants and find out how each one produces its new plants.

16. Make a list of plants that follow each method observed, and find out which method is most common and which is most rare.

17. Are there still other ways of growing new plants?

Experiment 5.—Many cuttings will grow if simply placed in a bottle of water, in which case the roots may be plainly seen as they develop. When they become large enough to sustain the plants, they may be transplanted into pots or into the school garden. Obtain in this way some flowering plants for the school.

LESSON LII

PLANT PROPAGATION—BUDDING

FIELD LESSON.—Visit a nursery and see how young trees are produced, cared for, and transplanted into orchards.

1. What fruit trees are grown from seeds?

2. What trees and shrubs are grown from cuttings? Hav- you ever seen green fence posts, set in moist soil, grow into trees?

3. Can you recognize the different varieties of young trees in a nursery as readily as when they are older?

4. Name and describe the fruit trees that you readily recognize.

5. Can an orchardist, in buying young trees, always tell whether they are the particular variety he wants or not? Why is it necessary that he should be sure what variety of fruit each tree will produce?

6. Do trees grown from seeds generally produce the same variety as the seeds planted? Why?

7. Are the trees and shrubs grown from cuttings always of the same variety as the cuttings used?

8. What does the nurseryman do to make sure that the fruit of any given tree will be the desired kind?

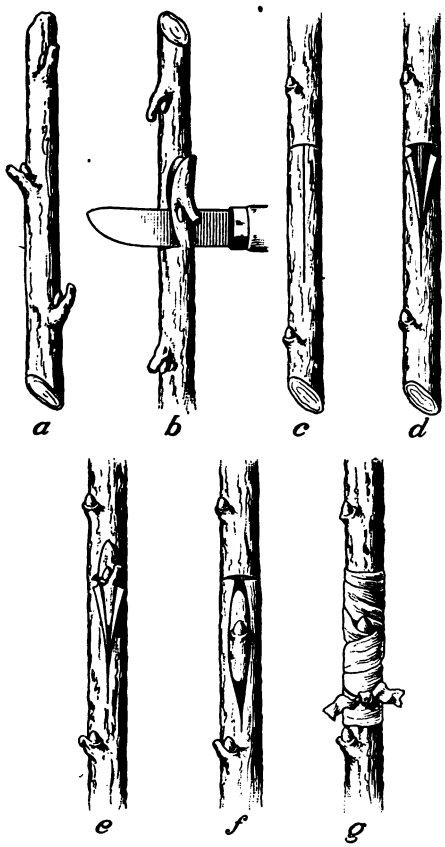
Note.—The variety is determined by the bud rather than by the root or stem. The nurseryman, therefore, takes buds from an old tree, whose variety is known, and "buds" or "grafts" into the seedling tree. "Budding" is usually done when the seedling is only a year old, but grafting may be done at almost any age.

9. What is the chief thing to secure the growth of the bud in its new home? Why must the sap of the young twig be made to circulate in the new bud?

10. When the new bud begins to grow, how may its growth be forced?

11. Why, in the nursery, are the young trees budded so near the ground?

12. What two advantages are secured by cutting off the



STEPS IN BUDDING

(*a*) twig having suitable buds to use; (*b*) method of cutting off the bud; (*c*) how the bark is cut; (*d*) how the bark is opened; (*e*) inserting the bud; (*f*) the bud in place; (*g*) the bud properly wrapped.

young tree just above the new bud as soon as the latter is big enough?

Experiment.—Although in the temperate zone, August is, perhaps, the best month to bud young trees, yet with care the young buds may be made to grow early in the spring while the sap is flowing freely. Bring twigs to the class and practice in cutting and placing buds of any kind until you are familiar with the process. Then bud young twigs of any tree that may be growing near the school, using buds of some other variety of the same tree.

13. How are strawberries propagated?

14. How does spearmint reproduce itself?

15. Describe how the successive crops of alfalfa grow.

16. How long does the banana tree live and how does it produce young plants?

17. What plants may be reproduced in more ways than one? Make a list of all that you know.

18. How may several kinds of fruit or flowers be made to grow on the same plant?

LESSON LIII

GRAFTING

1. In spite of all the care of the nurserymen in budding the young trees, in almost every large orchard there will be a few trees that, when mature, will not bear fruit true to name. What remedy can you think of for this condition?

STEPS IN TONGUE GRAFTING

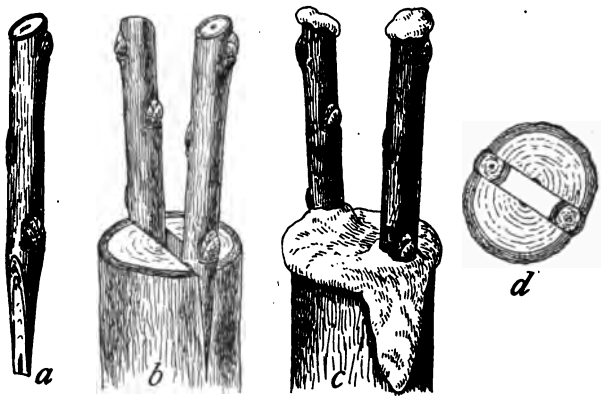
(*a*) the two branches to be joined; (*b*) a tongue cut in each; (*c*) how fitted together; (*d*) method of wrapping.

2. Why not dig up the old trees and plant young ones of the desired kind in their places?

3. Now that the bark is too thick and hard to "bud" the old trees, can you think of any other way in which the sap of the tree may be made to mingle with the sap of a twig of another tree that bears buds of the variety desired?

Experiment.—Saw off a limb of a tree and split the stump down the center, making a crack about three inches long (*b*). Cut two scions, each having several buds and trim one end of each into the shape of a long, slim wedge (*a*). Insert these into the crack in such a position (*b*) that the sap layer of each scion shall coincide with the sap layers on the two sides of the stump (*d*), so as to secure a circulation of sap between

them. The severed ends of both the stump and the scions should then be covered with grafting wax (*c*) to prevent their drying before growth is established.



STEPS IN CLEFT GRAFTING

4. What is the great advantage of grafting?

5. Why do grafts grow more rapidly than twigs on other branches of the same tree? than seedlings?

6. When the grafts are large enough, why should the other limbs be sawed off?

Note.—Usually in grafting, scions are inserted into more than one limb, and on different sides of the tree in order that the tree may be well balanced when the scions grow and the other limbs are cut off.

LESSON LIV

CHIEF CROPS OF THE UNITED STATES

TO THE TEACHER.—In teaching the influences of physical conditions upon crops and their consequent distribution, the work should correlate closely with geography. A knowledge of the nature of plants and

of the climate and conditions that they require will aid the pupils greatly in remembering where various ones are found; if, at the same time, they are taught the influence of position and surface conditions that determine climate, etc.

1. Mention plants that need much water. Make a list of these.

2. Name some desert or arid region plants.

3. Compare in a general way their size, growth, appearance, etc.

4. What plants require long, warm, summers to develop them?

5. What plants will develop in a short, cool summer?

6. How long does it take wheat to mature? corn? sugar cane? cotton? How does this influence their place of greatest growth?

Note.—A little flower growing near the snow line in the Rocky Mountains will sprout, blossom, develop, seed and scatter the seed, wither up, and die within the short space of six weeks, its summer. In the tropics, plants of similar size take almost a year to do this work.

7. What plants thrive best in sandy soil? clayey soil?

8. What kind of soil do most plants seem to like best?

9. What parts of the United States are warm and moist? What crops thrive best there?

10. What parts are dry and hot? What crops grow there?

11. What conditions of climate and soil do the following important crops require: wheat, corn, cotton, sugar, cane, tobacco, rice, cranberries, apples, grapes, etc.?

12. Where, in the United States, does each of these crops thrive best and why?

13. Where, in the United States, are oranges raised? Why?

14. What fruits are raised in the north? Why?

15. What influence does weather have upon crops in any locality? If the spring is late and cold and damp, how will it affect the crops? If it is early and hot and dry, what effect will it have upon them?

16. Where is sandy soil most frequently found? Where do we find gravel? clay?

17. Tell if the soil influences plant growth in any degree.

LESSON LV

PLANT STRUGGLES—WIND

Note.—One of the most interesting and instructive things to study is the behavior of plants when placed in unfavorable and dangerous conditions. The efforts that they put forth to save themselves from destruction are often ingenious and sometimes almost pathetic. These struggles can be seen almost any time and anywhere among plants. Some of their enemies may be only accidental or special, while others are permanent, and their means of protection will be special or permanent to correspond. Study the behavior of plants under different circumstances and learn to explain what you see.

1. What great good is done the plant by the wind? Recall the work of the wind in scattering the seeds of plants.

2. What habits have plants that are calculated to make the wind serve them?

3. If winds are too strong, what harm do they often do to plants? Tell of trees and fruit, hay and grain, etc., that you have seen injured by the wind.

4. How do trees guard against being uprooted?

5. Is it an advantage that the tall poplar tree bends before a strong wind? Why?

6. If the wind blows strongly and from the same direction, what will be its effect upon the shape of trees? Do you know of any trees whose shape has been changed by the wind? Can they withstand the force of the wind now better than before their shape had changed?

7. How are orchards and forests often injured by strong winds or hurricanes?

8. Describe the structure of trees as adapted to withstand the force of the wind. Consider the shape and size of the trunk, the arrangement of the branches, the strength of the roots, etc., and any special provision you may have seen.

ODE TO THE WEST WIND

I

O wild West Wind, thou breath of Autumn's being,
Thou, from whose unseen presence the leaves dead
Are driven, like ghosts from an enchanter fleeing,

Yellow, and black, and pale, and hectic red,
Pestilence-stricken multitudes: O thou,
Who chariotest to their dark wintry bed

The wingèd seeds, where they lie cold and low,
Each like a corpse within its grave, until
Thine azure sister of the spring shall blow

Her clarion o'er the dreaming earth, and fill
(Driving sweet buds like flocks to feed in air)
With living hues and odors plain and hill:

Wild Spirit, which art moving everywhere:
Destroyer and preserver; hear, Oh hear!

II

Thou on whose stream, mid the steep sky's commotion,
Loose clouds like earth's decaying leaves are shed,
Shook from the tangled boughs of Heaven and Ocean,

Angels of rain and lightning: there are spread
On the blue surface of thine airy surge,
Like the bright hair uplifted from the head

Of some fierce Mænad, even from the dim verge
Of the horizon to the zenith's height,
The locks of the approaching storm. Thou dirge

Of the dying year, to which this closing night
Will be the dome of a vast sepulchre,
Veiled with all thy congregated might

Of vapors, from whose solid atmosphere
Black rain, and fire, and hail will burst: Oh hear!

—SHELLEY.

LESSON LVI

PLANT STRUGGLES—DROUGHT

A FIELD LESSON.—After the spring rains have ceased and the dry, hot, weather begins, study any nearby patch of weeds and note how they act as their supply of moisture grows less.

1. Count the number of weeds growing on a square yard.
2. Note which are large and thrifty and which are small and weakly. Account for these differences as far as you can.
3. Compare these weeds with others near by and account for any marked difference between them.
4. What are the first signs of suffering for water?

5. Why do the leaves curl? Does this economize water? Explain.

6. Why do some dry and drop off, if the drought continues?

Experiment. 1.—Make a small hole in the center of a piece of paper or cardboard and cut a slit from the hole to the edge. Place this around the stem of any potted plant, and invert over it a glass jar as shown in the illustration. If placed in the sunshine, the water given off from the leaves of the plant as vapor will, in a short time, begin to collect on the inside of the jar. No moisture can come from the soil through the cardboard, so all of it must come from the plant.

7. Which weeds die first, the strong or the weak ones? Why?

8. Which survive the longer? Why? Consider the size of the plants; the depth reached by their roots; the number of plants near them that helped to use up the moisture; and the difference in soil if there be any.

9. Is the death of the weaker an advantage to the stronger? If so, why?

10. Is it an advantage to the species that some get a good start and become strong and deep-rooted before the dry season comes? Explain.

11. What does this fact mean in the broad field of nature? Would it be well for every plant of the same kind to be equal in size and endurance?

12. As it is now, which plants furnish most of the seeds that get scattered and grow, the strong ones or the weak?

Experiment 2.—Supply water regularly to a portion of the plants that are dying for thirst and describe the results.

13. Do they entirely overcome the effects of the drought?

14. Do they produce as many seeds and as large in size as though they had suffered no drought?

15. What advantage have irrigated crops in this respect over those that depend upon rain for their moisture?

Note.—One reason for the richer flavor of fruits raised in the arid regions, where they are irrigated regularly, over those raised where they depend upon rain, is that the growth of the former is never interrupted by drought, while the latter is retarded quite often and the fruit never fully recovers from the effect.

16. What is the effect of missing one's "watering turn" upon an irrigated farm?

17. Collect samples of plants for the school cabinet that will illustrate the effects of drought and abundance of water upon their growth.

18. How do plants that inhabit the arid regions permanently economize moisture? Are their leaves as numerous and as large as those growing in the humid regions?

LESSON LVII

PLANT STRUGGLES—NEIGHBORS

1. Why do we "weed "a garden? In what ways do weeds injure cultivated plants?

2. Why are crops of sugar beets "thinned?" At what age is this work done? Why?

3. Why is only half as much seed grain sown upon a dry farm as upon one that is irrigated in the arid regions?

4. Why are orchard trees thinned by pruning?

5. Do plants generally thrive as well in dense groups as in more scattered conditions?

6. What conditions will aid plants in growing in dense communities?

7. Why are wild plants thicker on a ditch bank than on an open, dryer piece of ground?

8. Is it profitable to plant a garden or to set out shrubs in an orchard where the trees are so large as to shade the ground?

9. Tell how different plants that you have seen continue to live in crowded places.

Experiment.—Select some common plant, as the dandelion, to study in relation to its neighbors, and report your observations to the class.

10. Describe its conduct on the lawn and how it escapes the lawn mower, and succeeds in developing its seeds and getting them scattered.

11. Tell how differently it acts in a meadow, in a field of alfalfa, or when surrounded by tall neighbors.

12. Observe and report upon how other plants adapt themselves to their surroundings.

13. What is the shape of a tree growing near the wall of a building? How do clumps of trees influence the shape of one another?

14. Is the undergrowth as dense in the woods where the foliage of the trees is dense as where it is open?

15. Do the same wild plants always grow in the same places or do they change from year to year?

16. Does nature ever rotate her crops as the farmer does?

17. Have you ever seen one community of plants run out another? How did it do it?

18. Why will dandelions run out lawn grass?

19. What advantages have weeds in a garden over the crops planted there?

20. Explain the difference between a well cultivated and a neglected garden.

LESSON LVIII

PLANT STRUGGLES—CLIMATE

1. What fruits grow in southern countries that will not grow here? Make a list of them.

2. What other trees or plants will grow there but not here?

3. What crops are raised here but not in countries far north of us? Make a list of them.

4. Why will not all these plants grow everywhere?

5. When do our latest frosts occur in the spring? When do our earliest ones come in the fall? Examine your Meteorological Records or the Weather Bureau reports.

7. How long a summer have our plants to develop their seeds without injury from frosts?

8. Can plants that require a longer time thrive in this latitude? Why?

9. How do the annual plants contrive to pass the cold winters, and produce like plants from year to year?

10. Are any of the seeds of wild annual plants here injured by the cold and wet? Are any of the seeds of the cultivated plants injured in that way?

11. What seeds are injured by freezing? Which are not?

12. How do the biennial plants manage to endure the rigors of our winters?

13. What precautions do plants take to escape being injured by winter weather?

14. Should a late frost in the spring kill the bursting buds on a tree, what would be the results?

15. How do the trees and other plants of the far north adapt themselves to the cold climate there? (Recall lessons 15 and 16, on evergreen and deciduous trees, pages 29 and 31.

16. Make a list of plants that grow in each of the zones.

LESSON LIX

PLANT STRUGGLES—ANIMALS

1. When the top of the grass is eaten off by animals, does it usually die?

2. Does mowing down weeds generally kill them?

3. What effect upon the grass has mowing the lawn?

Experiment.—Cut off the stems of several weeds and other plants at different distances from the roots and find out by the actual test where each kind must be cut to kill it. Also note the effort to survive when cut off above the fatal point.

4. In hoeing the garden, what use can we make of this knowledge?

5. When the central seed stock is eaten or cut off, why are others produced on the side?

6. When is this habit useful to man? When is it harmful to him?

7. How does this habit of plants affect the ranges?

8. Why will a herd of sheep destroy the grass on the range more quickly than a herd of cattle will? Which eats off the grass lower? Why?

9. At what point must most weeds be cut off to kill them?

10. Why do some weeds have to be plowed under to be destroyed?

11. In what ways do plants keep animals from eating them?

12. What plants have spines? Of what use are they?

13. What plants have a foul odor? a bad taste?

14. Do any plants use color in any way to protect themselves or their seeds from injury?

15. Why have most unripe fruits a green color and a bad taste?

16. Is the smooth skin of the apple, the fuzzy skin of the peach, the bony rind of the squash, a protection from any animal that would harm the seeds within?

17. Find how other plants are protected from the attacks of animals.

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